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Titanium aluminide application process and article with titanium aluminide surface

EP2584056

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor CALLA EKLAVYA SCHAEFFER JON CONRAD ANAND KRISHNAMURTHY AMANCHERLA SUNDAR • International Patent Classification B05D-001/02 B05D-003/00 B05D-003/02 B05D-003/12 B05D-007/24 C22C-014/00 C22C-021/00 C23C-004/06 C23C-024/04 C23C-028/00 F01D-005/00 F01D-025/00 • US Patent Classification PCLO=427421100 PCLX=420418000 PCLX=420552000 • CPC Code C22C-014/00; C23C-024/04; F01D-005/00/5; F01D-025/00; F05D-2230/80 	<ul style="list-style-type: none"> • Publication Information EP2584056 A1 2013-04-24 [EP2584056]  <ul style="list-style-type: none"> • Priority Details 2011US-13276568 2011-10-19 																				
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">EP2584056</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">2013-04-24</td> <td style="width: 30%;">[EP2584056]</td> </tr> <tr> <td>US2013101459</td> <td>A1</td> <td>2013-04-25</td> <td>[US20130101459]</td> </tr> <tr> <td>JP2013087364</td> <td>A</td> <td>2013-05-13</td> <td>[JP2013087364]</td> </tr> <tr> <td>US8475882</td> <td>B2</td> <td>2013-07-02</td> <td>[US8475882]</td> </tr> <tr> <td>RU2012145763</td> <td>A</td> <td>2014-04-27</td> <td>[RU2012145763]</td> </tr> </table> 		EP2584056	A1	2013-04-24	[EP2584056]	US2013101459	A1	2013-04-25	[US20130101459]	JP2013087364	A	2013-05-13	[JP2013087364]	US8475882	B2	2013-07-02	[US8475882]	RU2012145763	A	2014-04-27	[RU2012145763]
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RU2012145763	A	2014-04-27	[RU2012145763]																		

- **Abstract:**

(EP2584056)

A titanium aluminide application process and article with a titanium aluminide surface are disclosed. The process includes cold spraying titanium aluminide onto an article within a treatment region to form a titanium aluminide surface. The titanium aluminide surface includes a refined gamma/alpha2 structure and/or the titanium aluminide is cold sprayed from a solid feedstock of a pre-alloyed powder.


Claims

(EP2584056)

1. A titanium aluminide application process, comprising: cold spraying titanium aluminide onto an article within a treatment region to form a titanium aluminide surface; wherein the titanium aluminide surface includes a refined gamma/alpha2 structure.
2. The process of claim 1, wherein the titanium aluminide surface includes little or no equiaxed grains.
3. The process of claim 1 or claim 2, wherein the article is a turbine component.
4. The process of any preceding claim, wherein the titanium aluminide cold sprayed onto the article has a composition including, by weight, including about 45% titanium and about 50% aluminum.
5. The process of any preceding claim, wherein the titanium aluminide cold sprayed onto the article has a composition including Al 2Ti.
6. The process of any preceding claim, wherein the titanium aluminide cold sprayed onto the article has a composition including Al 3Ti.
7. The process of any preceding claim, wherein the cold spraying of titanium aluminide includes accelerating a solid feedstock with a converging-diverging nozzle.
8. The process of any preceding claim, wherein the titanium aluminide surface is directly on a substrate of the article.
9. The process of any preceding claim, wherein the titanium aluminide surface is on a bond coat on the article.
10. The process of any preceding claim, further comprising shot peening of the titanium aluminide surface.
11. The process of any preceding claim, further comprising heat treating the titanium aluminide surface.
12. The process of any preceding claim, further comprising finishing the titanium aluminide surface.
13. The process of any preceding claim, further comprising identifying a repair region within the treatment region prior to cold spraying the titanium aluminide.
14. The process of any preceding claim, further comprising removing material from the treatment region prior to cold spraying the titanium aluminide.
15. The process of claim 14, wherein the removing of the material includes a first sub-step of removal for identifying the repair region and a second sub-step for opening up the repair region.
16. The process of any preceding claim, further comprising cleaning within the treatment region prior to cold spraying the titanium aluminide.
17. The process of any preceding claim, wherein the solid feedstock is a pre-alloyed powder.
18. The process of any preceding claim, wherein the cold spraying of the titanium aluminide is part of a repair process.
19. A titanium aluminide application process of any preceding claim, comprising: cold spraying titanium aluminide onto an article within a treatment region to form a titanium aluminide surface; wherein the titanium aluminide cold sprayed is from a solid feedstock of a pre-alloyed powder.
20. An article, comprising a titanium aluminide surface, the titanium aluminide surface including a refined gamma/alpha2 structure.

Calcium titanate containing mold compositions and methods for casting titanium and titanium aluminide alloys

CA2881854

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC JAGUAR LAND ROVER • Inventor BEWLAY BERNARD PATRICK MCKIEVER JOAN ELLIS BRIAN MICHAEL MCLASKY NICHOLAS VINCENT • International Patent Classification B22C-001/00 B22C-001/06 B22C-001/18 B22C-009/00 B22C-009/04 B22C-009/22 B22D-011/00 B22D-011/04 B22D-011/055 B22D-021/00 B22D-021/02 B22D-021/06 B28B-007/00 B28B-007/34 B29C-033/00 B29C-033/38 B60W-030/14 B60W-040/04 B60W-040/105 C04B-028/06 C04B-035/101 C04B-035/44 C04B-035/46 • US Patent Classification PCL0=164529000 PCLX=106038300 PCLX=106038900 PCLX=106692000 PCLX=164131000 PCLX=164361000 PCLX=164519000 PCLX=264219000 PCLX=264220000 PCLX=264221000 PCLX=264225000 • CPC Code B22C-001/06; B22C-001/18/1; B22D-021/00/5; B22D-021/02/2; B60W-030/14/6; B60W-040/04; B60W-040/105; C04B-028/06; C04B-035/10; C04B-035/44; C04B-035/465; C04B-035/626/25; C04B-035/63/03; C04B-2111/00939; C04B-2235/3206; C04B-2235/3208; C04B-2235/3217; C04B-2235/3222; C04B-2235/3232; C04B-2235/3244; C04B-2235/3418; C04B-2235/528; C04B-2235/5427; C04B-2235/5436; C04B-2235/80 	<ul style="list-style-type: none"> • Publication Information CA2881854 A1 2014-03-06 [CA2881854]  <ul style="list-style-type: none"> • Priority Details 2012US-13598164 2012-08-29 2013US-14379993 2013-08-02 2013WO-US53385 2013-08-02 																																
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2881854</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">2014-03-06</td> <td style="width: 30%;">[CA2881854]</td> </tr> <tr> <td>WO2014035602</td> <td>A1</td> <td>2014-03-06</td> <td>[WO201435602]</td> </tr> <tr> <td>US2014060767</td> <td>A1</td> <td>2014-03-06</td> <td>[US20140060767]</td> </tr> <tr> <td>US8708033</td> <td>B2</td> <td>2014-04-29</td> <td>[US8708033]</td> </tr> <tr> <td>CN104582875</td> <td>A</td> <td>2015-04-29</td> <td>[CN104582875]</td> </tr> <tr> <td>EP2890509</td> <td>A1</td> <td>2015-07-08</td> <td>[EP2890509]</td> </tr> <tr> <td>JP2015534508</td> <td>A</td> <td>2015-12-03</td> <td>[JP2015534508]</td> </tr> <tr> <td>US2016031444</td> <td>A1</td> <td>2016-02-04</td> <td>[US20160031444]</td> </tr> </table> 		CA2881854	A1	2014-03-06	[CA2881854]	WO2014035602	A1	2014-03-06	[WO201435602]	US2014060767	A1	2014-03-06	[US20140060767]	US8708033	B2	2014-04-29	[US8708033]	CN104582875	A	2015-04-29	[CN104582875]	EP2890509	A1	2015-07-08	[EP2890509]	JP2015534508	A	2015-12-03	[JP2015534508]	US2016031444	A1	2016-02-04	[US20160031444]
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US2016031444	A1	2016-02-04	[US20160031444]																														

- **Abstract:**

(US20140060767)

The disclosure relates generally to mold compositions comprising calcium aluminate and calcium titanate. The disclosure also relates to methods of molding and the articles so molded using the mold compositions. More specifically, the disclosure relates to calcium aluminate/calcium titanate mold compositions and methods for casting titanium-containing articles, and the titanium-containing articles so molded. (From US8708033 B2)

Claims

(US20140060767)

1. A mold composition for casting a titanium-containing article, comprising: calcium titanate; and

a calcium aluminate cement comprising calcium monoaluminate.

2. The mold composition as recited in claim 1, wherein said calcium titanate comprises particles that are less than about 100 microns in outside dimension.

3. The mold composition as recited in claim 1, wherein said calcium titanate comprises from about 5% by weight to about 50% by weight of the mold composition.

4. The mold composition as recited in claim 1, further comprising aluminum oxide particles.

5. The mold composition as recited in claim 4, wherein said aluminum oxide particles comprise particles that are less than about 10 millimeters in outside dimension.

6. The mold composition as recited in claim 4, wherein said aluminum oxide particles comprise from about 5% by weight to about 70% by weight of the mold composition.

7. The mold composition as recited in claim 1, wherein said calcium aluminate cement comprises more than 20% by weight of the casting mold composition.

8. The mold composition as recited in claim 1, wherein said calcium aluminate cement further comprises calcium dialuminate, mayenite, or both calcium dialuminate and mayenite.

9. The mold composition as recited in claim 8, wherein said calcium monoaluminate comprises a weight fraction of about 0.05 to about 0.95; wherein said calcium dialuminate comprises a weight fraction of about 0.05 to about 0.80; and wherein said mayenite comprises a weight fraction of about 0.01 to about 0.30.

10. The mold composition as recited in claim 1, further comprising oxide particles.

11. The mold composition as recited in claim 10, wherein said oxide particles comprise aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or combinations thereof.

12. The mold composition as recited in claim 10, wherein said oxide particles comprise hollow oxide particles.

13. The mold composition as recited in claim 12, wherein said hollow oxide particles comprise hollow alumina particles.

14. The mold composition as recited in claim 1, further comprising calcium oxide.

15. The mold composition as recited in claim 14, wherein said calcium oxide comprises more than about 10% by weight and less than about 50% by weight of the mold composition.

16. The mold composition as recited in claim 1, further comprising titanium oxide.

17. The mold composition as recited in claim 16, wherein said titanium oxide comprises more than about 5% by weight and less than about 55% by weight of the mold composition.

18. The mold composition as recited in claim 1, further comprising silica.

19. The mold composition as recited in claim 1, wherein said mold composition comprises an investment casting mold composition for casting near-net-shape titanium aluminide articles.

20. A method for forming a casting mold for casting a titanium-containing article, said method comprising: combining calcium aluminate and calcium titanate with a liquid to produce a slurry of calcium aluminate and calcium titanate in the liquid;

introducing the slurry into a mold cavity that contains a fugitive pattern; and

allowing the slurry to cure in the mold cavity to form the casting mold of the titanium-containing article.

21. The method as recited in claim 20, wherein the method further comprises, before introducing the slurry into a mold cavity, introducing oxide particles to the slurry.

22. The method as recited in as recited in claim 21, wherein said oxide particles comprise aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, and compositions thereof.

23. The method as recited in claim 21, wherein said oxide particles comprise hollow oxide particles.

24. The method as recited in claim 23, wherein said hollow oxide particles comprise hollow alumina spheres.

25. The method as recited in claim 20, wherein silica is mixed with the calcium aluminate prior to combining the calcium aluminate and the calcium titanate with the liquid to produce the slurry, wherein said silica is provided as colloidal silica and/or particulate silica.

26. The method as recited in claim 20, wherein said casting mold comprises an investment casting mold for casting near-net-shape titanium aluminide articles.

27. The method as recited in claim 20, wherein the titanium-containing article comprises a titanium aluminide turbine blade.

28. The method as recited in claim 20, wherein the titanium-containing article comprises a near-net-shape, titanium aluminide turbine blade requiring little or no material removal prior to installation.

29. A casting method for titanium and titanium alloys comprising: obtaining an investment casting mold composition comprising calcium aluminate, calcium titanate, and aluminum oxide;

pouring said investment casting mold composition into a vessel containing a fugitive pattern;

curing said investment casting mold composition;

removing said fugitive pattern from the mold;

preheating the mold to a mold casting temperature;

pouring molten titanium or titanium alloy into the heated mold;

solidifying the molten titanium or titanium alloy and forming a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.


30. The casting method as recited in claim 29, wherein, between removing said fugitive pattern from the mold and preheating the mold to a mold casting temperature, heating said mold to a temperature of about 450 degrees Celsius to about 1200 degrees Celsius, and then allowing said mold to cool to about room temperature.

31. The casting method as recited in claim 29, wherein, between removing said fugitive pattern from the mold and preheating the mold to a mold casting temperature, heating said mold to a temperature of about 450 degrees Celsius to about 1200 degrees Celsius, and then allowing said mold to be maintained at a casting temperature of about 450 degrees Celsius to about 850 degrees Celsius for casting.

32. The casting method as recited in claim 29, wherein the removing of the fugitive pattern comprises at least one of melting, dissolution, ignition, oven dewaxing, furnace dewaxing, steam autoclave dewaxing, or microwave dewaxing.

Mold compositions and methods for casting titanium and titanium aluminide alloys

CA2852910

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK • International Patent Classification B22C-001/00 B22C-001/06 B22C-001/08 B22C-001/12 B22C-001/18 B22C-009/00 B22C-009/04 B22D-021/00 B22D-021/06 C04B-028/06 C04B-111/00 F01D-005/28 F02C-007/00 • US Patent Classification PCLO=106038270 PCLO=001001000 PCLX=106038200 PCLX=106038220 • CPC Code B22C-001/00 B22C-001/00; B22C-001/18/1; B22D-021/00/5; C04B-028/06; C04B-2111/00939 C04B-2111/00939; 	<ul style="list-style-type: none"> • Publication Information CA2852910 A1 2013-05-02 [CA2852910] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 2011US-13284312 2011-10-28 2012WO-US59842 2012-10-12 2014US-14512903 2014-10-13 																																								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2852910</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2013-05-02</td> <td style="width: 40%;">[CA2852910]</td> </tr> <tr> <td>WO2013062787</td> <td>A1</td> <td>2013-05-02</td> <td>[WO201362787]</td> </tr> <tr> <td>US2013108459</td> <td>A1</td> <td>2013-05-02</td> <td>[US20130108459]</td> </tr> <tr> <td>CN103889614</td> <td>A</td> <td>2014-06-25</td> <td>[CN103889614]</td> </tr> <tr> <td>EP2771139</td> <td>A1</td> <td>2014-09-03</td> <td>[EP2771139]</td> </tr> <tr> <td>US8858697</td> <td>B2</td> <td>2014-10-14</td> <td>[US8858697]</td> </tr> <tr> <td>JP2014532562</td> <td>A</td> <td>2014-12-08</td> <td>[JP2014532562]</td> </tr> <tr> <td>US2015040801</td> <td>A1</td> <td>2015-02-12</td> <td>[US20150040801]</td> </tr> <tr> <td>US9095893</td> <td>B2</td> <td>2015-08-04</td> <td>[US9095893]</td> </tr> <tr> <td>IN3568/CHENP/2014</td> <td>A</td> <td>2016-01-08</td> <td>[IN2014CN03568]</td> </tr> </table> 		CA2852910	A1	2013-05-02	[CA2852910]	WO2013062787	A1	2013-05-02	[WO201362787]	US2013108459	A1	2013-05-02	[US20130108459]	CN103889614	A	2014-06-25	[CN103889614]	EP2771139	A1	2014-09-03	[EP2771139]	US8858697	B2	2014-10-14	[US8858697]	JP2014532562	A	2014-12-08	[JP2014532562]	US2015040801	A1	2015-02-12	[US20150040801]	US9095893	B2	2015-08-04	[US9095893]	IN3568/CHENP/2014	A	2016-01-08	[IN2014CN03568]
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- **Abstract:**

(US20130108459)

The disclosure relates generally to mold compositions and methods of molding and the articles so molded. More specifically, the disclosure relates to mold compositions and methods for casting titanium-containing articles, and the titanium-containing articles so molded. (From US9095893 B2)

Claims

(US20130108459)

1. A mold composition for casting a titanium-containing article, comprising: a calcium aluminate cement comprising calcium monoaluminate, calcium dialuminate, and mayenite.
2. The mold composition as recited in claim 1, further comprising aluminum oxide particles.
3. The mold composition as recited in claim 2, wherein said aluminum oxide particles comprise particles that are less than about 500 microns in outside dimension.
4. The mold composition as recited in claim 2, wherein said aluminum oxide particles comprise from about 40% by weight to about 68% by weight of the mold composition.
5. The mold composition as recited in claim 1, wherein said calcium aluminate cement comprises more than 30% by weight of the casting mold composition.
6. The mold composition as recited in claim 1, wherein said calcium monoaluminate comprises a volume fraction of about 0.1 to about 0.8; wherein said calcium dialuminate comprises a volume fraction of about 0.1 to about 0.6; and wherein said mayenite comprises a volume fraction of about 0.01 to about 0.2.
7. The mold composition as recited in claim 1, further comprising oxide particles.
8. The mold composition as recited in claim 7, wherein said oxide particles comprise aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or compositions thereof.
9. The mold composition as recited in claim 7, wherein said oxide particles comprise hollow oxide particles.
10. The mold composition as recited in claim 9, wherein said hollow oxide particles comprise hollow alumina spheres.
11. The mold composition as recited in claim 1, further comprising calcium oxide.
12. The mold composition as recited in claim 11, wherein said calcium oxide comprises more than about 10% by weight and less than about 50% by weight of the mold composition.
13. The mold composition as recited in claim 1, wherein said mold composition comprises an investment casting mold composition for casting near-net-shape titanium aluminide articles.
14. A method for forming a casting mold for casting a titanium-containing article, said method comprising: combining calcium aluminate with a liquid to produce a slurry of calcium aluminate in the liquid;

introducing the slurry into a mold cavity that contains a fugitive pattern; and

allowing the slurry to cure in the mold cavity to form a mold of a titanium-containing article.

15. The method as recited in claim 14, wherein the method further comprises, before introducing the slurry into a mold cavity, introducing oxide particles to the slurry.
16. The method as recited in as recited in claim 15, wherein said oxide particles comprise aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or compositions thereof.
17. The method as recited in claim 15, wherein said oxide particles comprise hollow oxide particles.
18. The method as recited in claim 17, wherein said hollow oxide particles comprise hollow alumina spheres.
19. The method as recited in claim 14, wherein said casting mold comprises an investment casting mold for casting near-net-shape titanium aluminide articles.
20. A mold formed from the mold composition recited in claim 1.
21. A titanium-containing article formed in the mold recited in claim 20.
22. The titanium-containing metallic article as recited in claim 21, wherein the article comprises a titanium aluminide-containing article.
23. The titanium aluminide-containing article as recited in claim 22, wherein the article comprises a titanium aluminide turbine blade.
24. The titanium-containing metallic article as recited in claim 22, wherein the article comprises a near-net-shape, titanium aluminide turbine blade requiring little or no material removal prior to installation.
25. A casting method for titanium and titanium alloys comprising: obtaining an investment casting mold composition comprising calcium aluminate and aluminum oxide;

pouring said investment casting mold composition into a vessel containing a fugitive pattern;

curing said investment casting mold composition;

removing said fugitive pattern from the mold;

preheating the mold to a mold casting temperature;

pouring molten titanium or titanium alloy into the heated mold;

solidifying the molten titanium or titanium alloy and forming a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.

26. The casting method as recited in claim 25, wherein, between removing said fugitive pattern from the mold and preheating the mold to a mold casting temperature, heating said mold to a temperature of about 450 degrees Celsius to about 900 degrees


Celsius, and then allowing said mold to cool to about room temperature.

27. The casting method as recited in claim 25, wherein the removing of the fugitive pattern comprises at least one of melting, dissolution, ignition, oven dewaxing, furnace dewaxing, steam autoclave dewaxing, or microwave dewaxing.

28. The casting method as recited in claim 25, wherein after removing the solidified titanium or titanium alloy casting from the mold, the casting is inspected with one or both of X-ray radiography and Neutron radiography.

29. A titanium or titanium alloy article made by the casting method as recited in claim 25.

Titanium aluminide article with improved surface finish CA2805199

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK JANSSEN JONATHAN SEBASTIAN WEI BIN ZHOU YOU DONG • International Patent Classification B24B-019/14 B24B-031/00 B24C-001/00 B24C-001/04 B24C-003/32 B24C-011/00 C22F C22F-001/04 C22F-001/18 C23F-004/00 • US Patent Classification PCLO=451036000 • CPC Code B24C-001/04 	<ul style="list-style-type: none"> • Publication Information CA2805199 A1 2013-08-15 [CA2805199] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 2012US-13396908 2012-02-15 																																				
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2805199</td> <td style="width: 15%;">A1</td> <td style="width: 20%;">2013-08-15</td> <td style="width: 35%;">[CA2805199]</td> </tr> <tr> <td>US2013210320</td> <td>A1</td> <td>2013-08-15</td> <td>[US20130210320]</td> </tr> <tr> <td>EP2628568</td> <td>A1</td> <td>2013-08-21</td> <td>[EP2628568]</td> </tr> <tr> <td>CN103255420</td> <td>A</td> <td>2013-08-21</td> <td>[CN103255420]</td> </tr> <tr> <td>JP2013166236</td> <td>A</td> <td>2013-08-29</td> <td>[JP2013166236]</td> </tr> <tr> <td>IN0092/DEL/2013</td> <td>A</td> <td>2014-08-08</td> <td>[IN2013DE00092]</td> </tr> <tr> <td>US9011205</td> <td>B2</td> <td>2015-04-21</td> <td>[US9011205]</td> </tr> <tr> <td>BR102013002801</td> <td>A2</td> <td>2015-06-23</td> <td>[BR102013002801]</td> </tr> <tr> <td>EP2628568</td> <td>B1</td> <td>2016-02-10</td> <td>[EP2628568]</td> </tr> </table> 		CA2805199	A1	2013-08-15	[CA2805199]	US2013210320	A1	2013-08-15	[US20130210320]	EP2628568	A1	2013-08-21	[EP2628568]	CN103255420	A	2013-08-21	[CN103255420]	JP2013166236	A	2013-08-29	[JP2013166236]	IN0092/DEL/2013	A	2014-08-08	[IN2013DE00092]	US9011205	B2	2015-04-21	[US9011205]	BR102013002801	A2	2015-06-23	[BR102013002801]	EP2628568	B1	2016-02-10	[EP2628568]
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- **Abstract:**

(EP2628568)


Titanium-containing articles having improved surface finishes and methods for changing the surface of titanium containing articles, for example by removing overstock, are provided. One example method includes passing a fluid at high pressure across a surface of an titanium aluminide alloy-containing article, for example, a turbine blade, at high linear speed and deforming the surface of the titanium aluminide alloy-containing article, and removing material from the surface of the titanium aluminide alloy-containing article. Though aspects of the invention can be used in fabricating high performance turbine blades, the methods disclosed can be applied to the treatment of any titanium-containing article for which it is difficult to obtain an improved surface finish.

Claims

(EP2628568)

1. A method for removing material from a titanium aluminide alloy-containing article, comprising: providing a titanium aluminide alloy-containing article; passing a fluid at high pressure across a surface of said titanium aluminide alloy-containing article; deforming the surface of the titanium aluminide alloy-containing article; and removing material from the titanium aluminide alloy-containing article, wherein asperities and pits from the surface of the titanium aluminide alloy-containing article are removed without cracking or damaging the surface of the article.
2. The method as recited in claim 1, wherein the fluid is passed along with or concurrent to passing a medium of particles across the surface of the article, and wherein the fluid further comprises particles ranging from about 50 microns to about 400 microns.
3. The method as recited in either of claim 1 or 2, wherein the motion of the nozzle from which fluid at high pressure exits is selected from a group consisting of rotational, translational, oscillatory, or a combination thereof.
4. The method as recited in any one of the preceding claims, wherein the fluid is passed at about 2 inches per minute to about 100 inches per minute over the surface of the titanium aluminide alloy-containing article.
5. The method as recited in any one of the preceding claims, wherein the titanium aluminide alloy comprises a gamma titanium aluminide-based phase and an alpha 2 (Ti 3Al) phase.
6. A method for changing a surface of a titanium aluminide alloy-containing article, comprising: stabilizing the titanium aluminide alloy-containing article on a structure; passing a fluid across a surface of said stabilized titanium aluminide alloy-article at high linear speed; and deforming both a gamma titanium aluminide based phase and an alpha 2 (Ti 3Al) phase of the titanium aluminide alloy, wherein material is removed from the surface of the titanium aluminide alloy-containing article and thereby changing the surface of the article.
7. The method as recited in claim 6, wherein the fluid is passed along with or concurrent to passing a medium of particles ranging from about 50 microns to about 400 microns across the surface of the article.
8. The method as recited in either of claim 6 or 7, wherein the fluid is passed at about 5 inches per minute to about 1000 inches per minute over the surface of the titanium aluminide alloy-containing article.
9. The method as recited in any one of the preceding claims, wherein after the fluid is passed across the surface of the titanium aluminide alloy-containing article, the surface of the article is deformed over a depth of less than about 100 microns from the surface of the article and perpendicularly into the article.
10. The method as recited in any one of the preceding claims, wherein the titanium aluminide alloy-containing article comprises a titanium aluminide alloy-containing turbine blade.
11. The method as recited in any one of the preceding claims, wherein the fluid further comprises particles of alumina, garnet, silica, silicon carbide, boron carbide, diamond, tungsten carbide, and compositions thereof.
12. The method as recited in any one of the preceding claims, wherein the fluid is selected from a group consisting of water, oil, glycol, alcohol, or a combination thereof.
13. The method as recited in any one of the preceding claims, wherein particles ranging from about 50 microns to about 400 microns are suspended in the fluid before the fluid is passed across the surface of the article, and wherein the solids loading of the fluid is about 10% by 40% by mass flow.
14. A method for machining the surface of a titanium aluminide alloy-containing article, said method comprising: providing a titanium aluminide alloy-containing article; passing a fluid at high pressure across a surface of said titanium aluminide alloy-containing article; deforming the surface of the titanium aluminide alloy-containing article; and removing material from the surface of the titanium aluminide alloy-containing article.
15. A method for removing overstock material from the convex surface of an titanium aluminide containing turbine blade, said method comprising: providing a titanium aluminide alloy-containing turbine blade; passing a fluid at high pressure across the convex surface of said titanium aluminide containing turbine blade; and removing about 0.025 mm to about 5.0 mm of overstock material from the convex surface of the titanium aluminide containing turbine blade.

Electron beam welding to join gamma titanium aluminide articles US20040094246

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor KELLY THOMAS JOSEPH • International Patent Classification B23K-015/00 B23K-033/00 C22F-001/18 • US Patent Classification PCLO=148524000 PCLX=148669000 • CPC Code B23K-015/00/06; B23K-033/00 C22F-001/18/3; 	<ul style="list-style-type: none"> • Publication Information US20040094246 A1 2004-05-20 [US20040094246]  • Priority Details 2002US-10301767 2002-11-20 								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">US20040094246</td> <td style="width: 15%;">A1</td> <td style="width: 20%;">2004-05-20</td> <td style="width: 35%;">[US20040094246]</td> </tr> <tr> <td>US7413620</td> <td>B2</td> <td>2008-08-19</td> <td>[US7413620]</td> </tr> </table> 		US20040094246	A1	2004-05-20	[US20040094246]	US7413620	B2	2008-08-19	[US7413620]
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US7413620	B2	2008-08-19	[US7413620]						

- **Abstract:**

(US20040094246)

A method is provided for welding two gamma titanium aluminide articles together. The method includes preheating the two articles to a welding temperature of from about 1700° F. to about 2100° F., thereafter electron beam welding the two articles together at the welding temperature and in a welding vacuum to form a welded structure, and thereafter annealing the welded structure at an annealing temperature of from about 1800° F. to about 2200° F., to form a joined structure.

Claims

(US20040094246)

What is claimed is:

1.

A method for welding two gamma titanium aluminide articles together, comprising the steps of providing two articles, each made of gamma titanium aluminide material;

thereafter preheating the two articles to a welding temperature of from about 1700 deg. F. to about 2100 deg. F.;

thereafter electron beam welding the two articles together at the welding temperature and in a welding vacuum to form a welded structure;

and thereafter annealing the welded structure at an annealing temperature of from about 1800 deg. F. to about 2200 deg. F., to form a joined structure.

2. The method of claim 1, wherein the step of preheating includes the step of preheating the two articles in a preheating vacuum.

3. The method of claim 1, wherein the step of preheating includes the step of preheating the two articles to the welding temperature of about 1800 deg. F.

4. The method of claim 1, wherein the step of annealing includes the step of annealing the two articles in an annealing vacuum.

5. The method of claim 1, wherein the step of annealing includes the step of annealing the welded structure at the annealing temperature of about 2000 deg. F.

6. The method of claim 1, wherein the step of annealing includes the step of annealing the welded structure at the annealing temperature for a time of at least about 2 hours.

7. The method of claim 1, wherein the step of annealing includes the step of fabricating the joined structure as a component of a gas turbine engine.

8. The method of claim 1, wherein the method includes an additional step of providing a preheating device inside an electron beam vacuum chamber, and wherein the step of preheating includes the steps of placing the two articles in the preheating device at room temperature, and evacuating the electron beam vacuum chamber, prior to heating of the two articles to the welding temperature.

9. The method of claim 1, wherein the step of providing two articles includes the step of providing at least one of the two articles that is at least about 0.5 inch thick, and wherein the step of electron beam welding includes the step of electron beam welding the two articles through their entire thicknesses.

10. The method of claim 1, wherein the step of electron beam welding includes the step of forming a deep-penetration weld wherein a depth of the weldment is at least about 0.3 inches.

11. A method for welding two gamma titanium aluminide articles together, comprising the steps of providing two articles, each made of gamma titanium aluminide material;

thereafter preheating the two articles from room temperature to a welding temperature of from about 1700 deg. F. to about 2100 deg. F. in a preheating vacuum and maintaining the articles at the welding temperature for a time sufficient to thermally equilibrate the two articles;

thereafter electron beam welding the two articles together at the welding temperature and in a welding vacuum to form a welded structure;

and thereafter annealing the welded structure at an annealing temperature of from about 1800 deg. F. to about 2200 deg. F. in an annealing vacuum and for a time of at least about 2 hours, to form a joined structure that is a component of a gas turbine engine.

12. The method of claim 11, wherein the method includes an additional step of providing a preheating device inside an electron beam vacuum chamber, and wherein the step of preheating includes a step of placing the two articles in the preheating device at room temperature.

13. The method of claim 11, wherein the step of preheating includes the step of preheating the two articles to the welding temperature of about 1800 deg. F.

14. The method of claim 11, wherein the step of annealing includes the step of annealing the welded structure at the annealing temperature of about 2000 deg. F.


15. The method of claim 11, wherein the method includes an additional step of providing a preheating device inside an electron beam vacuum chamber, and wherein the step of preheating includes the steps of placing the two articles in the preheating device at room temperature, and evacuating the electron beam vacuum chamber, prior to any heating of the two articles to the welding temperature.

16. The method of claim 11, wherein the step of providing two articles includes the step of providing at least one of the two articles that is at least about 0.5 inch thick, and wherein the step of electron beam welding includes the step of electron beam welding the two articles through their entire thicknesses.

17. The method of claim 11, wherein the step of electron beam welding includes the step of forming a deep-penetration weld wherein a depth of the weldment is at least about 0.3 inches.

Silicon carbide-containing mold and facecoat compositions and methods for casting titanium and titanium aluminide alloys

US20150144286

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK MCKIEVER JOAN ELLIS BRIAN MICHAEL MCCLASKY NICHOLAS VINCENT • International Patent Classification B22C-001/00 B22C-003/00 B22C-007/02 B22C-009/02 B22C-009/22 C04B-041/50 C08K-003/22 C08K-003/34 C09D-001/00 • US Patent Classification PCLO=164349000 PCLX=428220000 • CPC Code B22C-001/00; B22C-003/00; B22C-009/02; B22C-009/22; C08K-003/22; C08K-003/34; C08K-2003/2206; C08K-2003/2227; C09D-001/00 	<ul style="list-style-type: none"> • Publication Information US2015144286 A1 2015-05-28 [US20150144286]  • Priority Details 2013US-14090773 2013-11-26 																
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">US2015144286</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2015-05-28</td> <td style="width: 40%;">[US20150144286]</td> </tr> <tr> <td>WO2015112232</td> <td>A2</td> <td>2015-07-30</td> <td>[WO2015112232]</td> </tr> <tr> <td>WO2015112232</td> <td>A3</td> <td>2015-10-08</td> <td>[WO2015112232]</td> </tr> <tr> <td>US9192983</td> <td>B2</td> <td>2015-11-24</td> <td>[US9192983]</td> </tr> </table> 		US2015144286	A1	2015-05-28	[US20150144286]	WO2015112232	A2	2015-07-30	[WO2015112232]	WO2015112232	A3	2015-10-08	[WO2015112232]	US9192983	B2	2015-11-24	[US9192983]
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- **Abstract:**

(US20150144286)

The disclosure relates generally to mold compositions and methods of molding and the articles so molded. More specifically, the disclosure relates to silicon carbide-containing mold compositions, silicon carbide-containing intrinsic facecoat compositions, and methods for casting titanium-containing articles, and the titanium-containing articles so molded.

Claims


(US20150144286)

1. A mold for casting a titanium-containing article, comprising: a calcium aluminate cement comprising calcium monoaluminate, calcium dialuminate, and mayenite, wherein said mold has a silicon carbide-containing intrinsic facecoat of about 10 microns to about 500 microns between a bulk of the mold and a mold cavity.
2. The mold as recited in claim 1, wherein the silicon carbide-containing intrinsic facecoat is a continuous intrinsic facecoat.
3. The mold as recited in claim 1, wherein the silicon carbide is present at about 15% to about 45% by weight.
4. The mold as recited in claim 1, wherein the mold comprises the bulk of the mold and the silicon carbide-containing intrinsic facecoat, and wherein the bulk of the mold and the silicon carbide-containing intrinsic facecoat have different compositions and wherein the silicon carbide-containing intrinsic facecoat comprises calcium aluminate with a particle size of less than about 50 microns.
5. The mold as recited in claim 1, wherein the mold comprises the bulk of the mold and the silicon carbide-containing intrinsic facecoat, and wherein the bulk of the mold and the silicon carbide-containing intrinsic facecoat have different compositions and wherein the bulk of the mold comprises alumina particles larger than about 50 microns.
6. The mold as recited in claim 1, wherein the mold comprises the bulk of the mold and the silicon carbide-containing intrinsic facecoat, and wherein the bulk of the mold comprises alumina particles larger than about 50 microns and the silicon carbide-containing intrinsic facecoat comprises calcium aluminate particles less than about 50 microns in size.
7. The mold as recited in claim 1, wherein the silicon carbide-containing intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate than does the bulk of the mold.
8. The mold as recited in claim 1, wherein the silicon carbide-containing intrinsic facecoat further comprises alumina and the level of alumina, by weight fraction, is at least 20 percent less than is present in the bulk of the mold.
9. The mold as recited in claim 1, wherein the silicon carbide-containing intrinsic facecoat further comprises alumina and the level of alumina, by weight fraction, is at least 20 percent less than is present in the bulk of the mold, and wherein the silicon carbide-containing intrinsic facecoat has at least 20 percent more calcium aluminate, and at least 50 percent less mayenite than does the bulk of the mold.
10. The mold as recited in claim 1, further comprising silicon carbide wherein the silicon carbide-containing intrinsic facecoat has, by weight fraction, at least 10 percent more silicon carbide than the bulk of the mold.
11. The mold as recited in claim 1, wherein the weight fraction of calcium monoaluminate in the silicon carbide-containing intrinsic facecoat is more than 0.45 and the weight fraction of mayenite is less than 0.10.
12. The mold as recited in claim 1, wherein said calcium monoaluminate in the bulk of the mold comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the silicon carbide-containing intrinsic facecoat is about 0.10 to 0.90.
13. The mold as recited in claim 1, wherein said calcium dialuminate in the bulk of the mold comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the silicon carbide-containing intrinsic facecoat is about 0.05 to 0.90.
14. The mold as recited in claim 1, wherein said mayenite in the bulk of the mold composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the silicon carbide-containing intrinsic facecoat is about 0.001 to 0.05.
15. The mold composition as recited in claim 1, wherein said calcium monoaluminate in the bulk of the mold comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the silicon carbide-containing intrinsic facecoat is about 0.1 to 0.9; said calcium dialuminate in the bulk of the mold comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the silicon carbide-containing intrinsic facecoat is about 0.05 to 0.90; and wherein said mayenite in the bulk of the mold composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the silicon carbide-containing intrinsic facecoat is about 0.001 to 0.05.
16. The mold as recited in claim 1, further comprising aluminum oxide particles in the bulk of the mold that are less than about 500 microns in outside dimension.
17. The mold as recited in claim 1, wherein the calcium aluminate comprises more than 20% by weight of the composition used to make the mold.
18. The mold as recited in claim 1, further comprising aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or compositions thereof.
19. The mold as recited in claim 18, wherein said aluminum oxide particles comprise from about 30% by weight to about 68% by weight of the composition used to make the mold.
20. The mold as recited in claim 1, further comprising hollow particles of aluminum oxide.
21. The mold as recited in claim 1, further comprising calcium oxide with more than about 10% by weight and less than about 50% by weight of the mold composition in calcium oxide.
22. The mold as recited in claim 1, wherein a percentage of solids in an initial calcium aluminate-liquid cement mixture used to make the mold is about 60 to about 78%.
23. The mold as recited in claim 1, wherein a percentage of solids in a final calcium aluminate-liquid cement mixture with large scale alumina used to make the mold, is from about 70% to about 95%.
24. The mold as recited in claim 1, wherein the mold further comprises less than 2% silica.
25. A facecoat composition of a mold that is used for casting a titanium-containing article, comprising: calcium monoaluminate, calcium dialuminate, silicon carbide, and mayenite, wherein said facecoat composition is a silicon carbide-containing intrinsic facecoat, is about 10 microns to about 500 microns thick, and is located between a bulk of the mold and a surface of the mold that opens to a mold cavity.
26. The facecoat composition of claim 25, wherein the silicon carbide-containing facecoat comprises calcium aluminate having a particle size of less than about 50 microns.
27. The facecoat composition as recited in claim 26, wherein the silicon carbide-containing intrinsic facecoat has, by weight fraction, at least 20 percent more calcium aluminate, at least 20 percent less alumina, and at least 50 percent less mayenite than does the bulk of the mold.

28. The facecoat composition as recited in claim 25, wherein the weight fraction of calcium monoaluminate in the silicon carbide-containing intrinsic facecoat is more than 0.45 and the weight fraction of mayenite is less than 0.10.
29. The facecoat composition of claim 25, further comprising silicon carbide wherein the silicon carbide-containing intrinsic facecoat has, by weight fraction, at least 10 percent more silicon carbide than does the bulk of the mold.
30. The facecoat composition of claim 25, further comprising silicon carbide wherein the silicon carbide is present at about 15% to about 45% by weight of the facecoat composition.

Thermomechanically processed structural elements of titanium aluminides containing chromium, niobium, and boron

IT91MI3446

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-001/00 C22C-001/02 C22C-014/00 C22F-001/00 C22F-001/18 • US Patent Classification PCLO=420418000 PCLO=148670000 PCLX=148421000 PCLX=148670000 PCLX=148671000 PCLX=420417000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information ITMI913446 D0 1991-12-20 [IT91MI3446] <li style="text-align: right;"> • Priority Details 1990US-07631989 1990-12-21 1992US-07884360 1992-05-18 																																																																
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 30%;">ITMI913446</td> <td style="width: 15%;">D0</td> <td style="width: 15%;">1991-12-20</td> <td style="width: 40%;">[IT91MI3446]</td> </tr> <tr> <td>GB9125740</td> <td>D0</td> <td>1992-01-29</td> <td>[GB9125740]</td> </tr> <tr> <td>ITMI913446</td> <td>A1</td> <td>1992-06-22</td> <td>[IT91MI3446]</td> </tr> <tr> <td>CA2056465</td> <td>A1</td> <td>1992-06-22</td> <td>[CA2056465]</td> </tr> <tr> <td>GB2251000</td> <td>A</td> <td>1992-06-24</td> <td>[GB2251000]</td> </tr> <tr> <td>DE4140679</td> <td>A1</td> <td>1992-06-25</td> <td>[DE4140679]</td> </tr> <tr> <td>FR2670804</td> <td>A1</td> <td>1992-06-26</td> <td>[FR2670804]</td> </tr> <tr> <td>US5204058</td> <td>A</td> <td>1993-04-20</td> <td>[US5204058]</td> </tr> <tr> <td>US5264054</td> <td>A</td> <td>1993-11-23</td> <td>[US5264054]</td> </tr> <tr> <td>JPH0617211</td> <td>A</td> <td>1994-01-25</td> <td>[JP06017211]</td> </tr> <tr> <td>FR2670804</td> <td>B1</td> <td>1994-05-13</td> <td>[FR2670804]</td> </tr> <tr> <td>GB2251000</td> <td>B</td> <td>1995-06-14</td> <td>[GB2251000]</td> </tr> <tr> <td>IT1252706</td> <td>B</td> <td>1995-06-26</td> <td>[IT1252706]</td> </tr> <tr> <td>JPH089761</td> <td>B2</td> <td>1996-01-31</td> <td>[JP96009761]</td> </tr> <tr> <td>DE4140679</td> <td>C2</td> <td>1997-04-24</td> <td>[DE4140679]</td> </tr> <tr> <td>CA2056465</td> <td>C</td> <td>2001-10-02</td> <td>[CA2056465]</td> </tr> </tbody> </table>		ITMI913446	D0	1991-12-20	[IT91MI3446]	GB9125740	D0	1992-01-29	[GB9125740]	ITMI913446	A1	1992-06-22	[IT91MI3446]	CA2056465	A1	1992-06-22	[CA2056465]	GB2251000	A	1992-06-24	[GB2251000]	DE4140679	A1	1992-06-25	[DE4140679]	FR2670804	A1	1992-06-26	[FR2670804]	US5204058	A	1993-04-20	[US5204058]	US5264054	A	1993-11-23	[US5264054]	JPH0617211	A	1994-01-25	[JP06017211]	FR2670804	B1	1994-05-13	[FR2670804]	GB2251000	B	1995-06-14	[GB2251000]	IT1252706	B	1995-06-26	[IT1252706]	JPH089761	B2	1996-01-31	[JP96009761]	DE4140679	C2	1997-04-24	[DE4140679]	CA2056465	C	2001-10-02	[CA2056465]
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FR2670804	B1	1994-05-13	[FR2670804]																																																														
GB2251000	B	1995-06-14	[GB2251000]																																																														
IT1252706	B	1995-06-26	[IT1252706]																																																														
JPH089761	B2	1996-01-31	[JP96009761]																																																														
DE4140679	C2	1997-04-24	[DE4140679]																																																														
CA2056465	C	2001-10-02	[CA2056465]																																																														

- **Abstract:**

(US5204058)

A method for providing improved ductility in a gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing chromium, carbon, and niobium and thermomechanically working the casting. Boron additions are made in concentrations between 0.5 and 2 atomic percent. Fine grain equiaxed microstructure is found from solidified melt. Property improvements are achieved by the thermomechanical processing.

Claims

(US5204058)

What is claimed is:

1.

A structural element, said element having the following approximate composition:

Ti42.8-53.5 Al43-48 Cr1-3 Nb2-4 B0.5-2.0 C0.05-0.2 and have been thermomechanically processed.

2. A structural element, said element having the following approximate composition:

Ti45.8-50.5 Al44.5-46.5 Cr2 Nb2-4 B1.0-1.5 C0.05-0.2 and have been thermomechanically processed.

3. A structural element, said element having the following approximate composition:


Ti44.8-49.5 Al44.5-46.5 Cr1-3 Nb4 B4 B1.0-1.5 C0.05-0.2 and have been thermomechanically processed.

4. A structural element, said element having the following approximate composition:

Ti45.8-48.5 Al44.5-46.5 Cr2 Nb4 B1.0-1.5 C0.05-0.2 and have been thermomechanically processed.

Crucible and facecoat compositions and methods for melting titanium and titanium aluminide alloys

CA2879437

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK BANCHERI STEPHEN MCKIEVER JOAN ELLIS BRIAN GIDDINGS ROBERT A • International Patent Classification B22D-021/06 B22D-041/00 B22D-041/02 B28B-001/00 C04B-035/00 C04B-035/117 C04B-035/44 C04B-035/626 C22C-001/02 F27B-014/10 F27D-001/00 H05B-006/24 • US Patent Classification PCLO=266286000 PCLX=266275000 PCLX=432265000 • CPC Code B22D-041/00; B22D-041/02; B28B-001/00/8; C04B-035/117; C04B-035/44; C04B-035/626/3; C04B-035/626/9; C04B-2235/3206; C04B-2235/3208; C04B-2235/3217; C04B-2235/3222; C04B-2235/3232; C04B-2235/3244 C04B-2235/3244; C04B-2235/3418; C04B-2235/5436; C04B-2235/6028; C04B-2235/80; F27B-014/10; F27D-001/00/06 F27D-001/00/06; 	<ul style="list-style-type: none"> • Publication Information CA2879437 A1 2014-01-30 [CA2879437]  <ul style="list-style-type: none"> • Priority Details 2012US-13559656 2012-07-27 2013WO-US50850 2013-07-17 																												
<ul style="list-style-type: none"> • Fampat family <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2879437</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">2014-01-30</td> <td style="width: 30%;">[CA2879437]</td> </tr> <tr> <td>WO2014018330</td> <td>A1</td> <td>2014-01-30</td> <td>[WO201418330]</td> </tr> <tr> <td>US2014030138</td> <td>A1</td> <td>2014-01-30</td> <td>[US20140030138]</td> </tr> <tr> <td>US8906292</td> <td>B2</td> <td>2014-12-09</td> <td>[US8906292]</td> </tr> <tr> <td>CN104662387</td> <td>A</td> <td>2015-05-27</td> <td>[CN104662387]</td> </tr> <tr> <td>EP2877797</td> <td>A1</td> <td>2015-06-03</td> <td>[EP2877797]</td> </tr> <tr> <td>JP2015531733</td> <td>A</td> <td>2015-11-05</td> <td>[JP2015531733]</td> </tr> </table> 		CA2879437	A1	2014-01-30	[CA2879437]	WO2014018330	A1	2014-01-30	[WO201418330]	US2014030138	A1	2014-01-30	[US20140030138]	US8906292	B2	2014-12-09	[US8906292]	CN104662387	A	2015-05-27	[CN104662387]	EP2877797	A1	2015-06-03	[EP2877797]	JP2015531733	A	2015-11-05	[JP2015531733]
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JP2015531733	A	2015-11-05	[JP2015531733]																										

- **Abstract:**

(US20140030138)

Crucible compositions and methods of using the crucible compositions to melt titanium and titanium alloys. More specifically, crucible compositions having intrinsic facecoats that are effective for melting titanium and titanium alloys for use in casting titanium-containing articles. Further embodiments are titanium-containing articles made from the titanium and titanium alloys melted in the crucible compositions. Another embodiment is a crucible curing device and methods of use thereof. (From US8906292 B2)

Claims

(US20140030138)

1. A crucible for melting titanium and titanium alloys, comprising: a bulk comprising a calcium aluminate cement, said calcium aluminate cement comprising calcium monoaluminate; and

a cavity for melting titanium and titanium alloys therein.

2. The crucible as recited in claim 1 further comprising: an intrinsic facecoat that is disposed about 10 microns to about 450 microns between the bulk and the cavity, wherein said intrinsic facecoat comprises a calcium aluminate cement comprising calcium monoaluminate.

3. The crucible as recited in claim 2, wherein the intrinsic facecoat comprises a continuous intrinsic facecoat or a non-continuous intrinsic facecoat.

4. The crucible as recited in claim 2, wherein said calcium aluminate cement further comprises calcium dialuminate, mayenite, or both calcium dialuminate and mayenite.

5. The crucible as recited in claim 2, wherein the bulk of the crucible and the intrinsic facecoat have different compositions and the intrinsic facecoat comprises calcium aluminate with a particle size of less than about 50 microns.

6. The crucible as recited in claim 2, wherein the bulk of the crucible and the intrinsic facecoat have different compositions and wherein the bulk of the crucible comprises alumina particles larger than about 50 microns.

7. The crucible as recited in claim 2, wherein the bulk of the crucible comprises alumina particles larger than about 50 microns and the intrinsic facecoat comprises calcium aluminate particles less than about 50 microns in size.

8. The crucible as recited in claim 2, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate than does the bulk of the crucible.

9. The crucible as recited in claim 2, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent less alumina than does the bulk of the crucible.

10. The crucible as recited in claim 4, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate, at least 20 percent less alumina, and at least 50 percent less mayenite than does the bulk of the crucible.

11. The crucible as recited in claim 4, wherein the weight fraction of calcium monoaluminate in the intrinsic facecoat is more than 0.60 and the weight fraction of mayenite is less than 0.10.

12. The crucible as recited in claim 2, wherein said calcium monoaluminate in the bulk of the crucible comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the intrinsic facecoat is about 0.10 to 0.90.

13. The crucible as recited in claim 4, wherein said calcium dialuminate in the bulk of the crucible comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat is about 0.05 to 0.90.

14. The crucible as recited in claim 4, wherein said mayenite in the bulk of the crucible composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat is about 0.001 to 0.05.

15. The crucible composition as recited in claim 4, wherein said calcium monoaluminate in the bulk of the crucible comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the intrinsic facecoat is about 0.1 to 0.9; said calcium dialuminate in the bulk of the crucible comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat is about 0.05 to 0.90; and wherein said mayenite in the bulk of the crucible composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat is about 0.001 to 0.05.

16. The crucible as recited in claim 1, further comprising aluminum oxide particles in the bulk of the crucible that are less than about 500 microns in outside dimension.

17. The crucible as recited in claim 1, wherein the calcium aluminate cement comprises more than 30% by weight of the composition used to make the crucible.

18. The crucible as recited in claim 1, further comprising aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or compositions thereof.

19. The crucible as recited in claim 18, wherein said aluminum oxide particles comprise from about 40% by weight to about 68% by weight of the composition used to make the crucible.

20. The crucible as recited in claim 1, further comprising hollow particles of aluminum oxide.

21. The crucible as recited in claim 1, further comprising more than about 10% by weight and less than about 50% by weight of the crucible composition in calcium oxide.

22. The crucible as recited in claim 1, wherein the percentage of solids in an initial calcium aluminate-liquid cement mixture used to make the crucible is from about 60 to about 80%.

23. The crucible as recited in claim 1, wherein the percentage of solids in the final calcium aluminate-liquid cement mixture with large scale alumina used to make the crucible is from about 65% to about 90%.

24. The crucible as recited in claim 1, wherein the crucible further comprises silica.

25. The crucible as recited in claim 1, wherein the crucible meets thermal shock resistance requirements for melting titanium or titanium alloys for use in a mold that forms a titanium-containing article.

26. The crucible as recited in claim 25, wherein the thermal shock resistance requirements for melting the titanium or titanium alloys at a temperature of more than 1500 deg. C., and up to 1700 deg. C. for at least 1 second.

27. The crucible as recited in claim 25, wherein the titanium-containing article comprises a titanium aluminide-containing turbine blade.

28. A method for forming a crucible for melting titanium and titanium alloys useful in making a titanium-containing article, said method comprising: combining calcium aluminate with a liquid to produce a slurry of calcium aluminate, wherein the percentage of solids in the initial calcium aluminate/liquid mixture is about 60% to about 80% and the viscosity of the slurry is about 50 to about 150 centipoise;

adding oxide particles into the slurry such that the solids in the final calcium aluminate/liquid mixture with the large-scale oxide

particles is about 65% to about 90%;

introducing the slurry into a crucible mold cavity; and

allowing the slurry to cure in the crucible mold cavity to form a crucible for use in melting titanium and titanium alloys useful in making a titanium-containing article,

wherein said allowing step comprises curing the slurry around a removable crucible cavity pattern inserted into the crucible mold cavity either prior to said introducing step or after said introducing step.

29. The method as recited in claim 28 further comprising firing the formed crucible.

30. A method for melting titanium and titanium alloys, said method comprising: providing a crucible made according to the method of claim 28;

preheating the crucible; and

melting titanium or a titanium alloy in the heated crucible to produce molten titanium or molten titanium alloy.

31. A casting method for titanium and titanium alloys, said method comprising: performing the method according to claim 30 to yield molten titanium or molten titanium alloy;

pouring the molten titanium or the molten titanium alloy into an investment mold;

solidifying the molten titanium or the molten titanium alloy to form a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.

32. A titanium or titanium alloy article made by the casting method as recited in claim 31.

33. A casting method for titanium and titanium alloys, said method comprising: performing the method according to claim 31 to yield molten titanium or molten titanium alloy;

pouring the molten titanium or the molten titanium alloy into an investment mold;

solidifying the molten titanium or the molten titanium alloy to form a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.

34. A crucible curing device comprising: a base comprising a chamber for holding a crucible mold therein;

an effector arm for inserting and removing a removable crucible cavity pattern into and out of the chamber, said effector arm comprising an adaptor portion for removably coupling the crucible cavity pattern to a terminal end of the effector arm; and

a support for supporting and positioning the effector arm at a desired location above the chamber,

wherein said crucible curing device is effective to produce a crucible that meets thermal shock resistance required for melting titanium or titanium alloys for use in forming a titanium-containing article.

35. A method for producing a crucible for melting titanium or titanium alloys for use in forming a titanium-containing article, said method comprising: providing a crucible curing device of claim 34;

positioning a crucible mold in the chamber of the crucible curing device, said crucible mold comprising a crucible mold cavity;

introducing a slurry of calcium aluminate into the crucible mold cavity of the crucible mold positioned in the chamber; and

allowing the slurry to cure in the crucible mold cavity to form a crucible for use in melting titanium and titanium alloys for forming a titanium-containing article,


wherein said allowing step comprises curing the slurry around the removable crucible cavity pattern inserted into the crucible mold cavity either prior to said introducing step or after said introducing step.

36. The method as recited in claim 35, wherein the slurry is produced by the process as follows: combining calcium aluminate with a liquid to produce a slurry of calcium aluminate, wherein the percentage of solids in the initial calcium aluminate/liquid mixture is about 60% to about 80% and the viscosity of the slurry is about 50 to about 150 centipoise; and

adding oxide particles into the slurry such that the solids in the final calcium aluminate/liquid mixture with the large-scale oxide particles is about 65% to about 90%.

Mold and facecoat compositions and methods for casting titanium and titanium aluminide alloys

CA2806844

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK BANCHERI STEPHEN WEIMER MICHAEL MCKIEVER JOAN ELLIS BRIAN • International Patent Classification B22C-001/00 B22C-001/08 B22C-003/00 B22C-007/02 B22C-009/00 B22C-009/04 B22C-009/12 B22C-009/22 B22D-015/00 B22D-021/02 B22D-021/06 C04B-007/32 C22C-014/00 • US Patent Classification PCLO=420417000 PCLO=164529000 PCLX=106038270 PCLX=164520000 PCLX=249114100 • CPC Code B22C-001/00; B22C-007/02; B22C-009/04; B22C-009/22 B22C-009/22; B22D-021/02/2 B22D-021/02/2; 	<ul style="list-style-type: none"> • Publication Information CA2806844 A1 2013-08-29 [CA2806844]  <ul style="list-style-type: none"> • Priority Details 2012US-13407917 2012-02-29 2015US-14595533 2015-01-13 																																								
<ul style="list-style-type: none"> • Fampat family <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2806844</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2013-08-29</td> <td style="width: 40%;">[CA2806844]</td> </tr> <tr> <td>US2013224066</td> <td>A1</td> <td>2013-08-29</td> <td>[US20130224066]</td> </tr> <tr> <td>CN103286256</td> <td>A</td> <td>2013-09-11</td> <td>[CN103286256]</td> </tr> <tr> <td>JP2013180344</td> <td>A</td> <td>2013-09-12</td> <td>[JP2013180344]</td> </tr> <tr> <td>EP2659994</td> <td>A2</td> <td>2013-11-06</td> <td>[EP2659994]</td> </tr> <tr> <td>BR102013004515</td> <td>A2</td> <td>2014-04-22</td> <td>[BR102013004515]</td> </tr> <tr> <td>IN0279/DEL/2013</td> <td>A</td> <td>2014-08-08</td> <td>[IN2013DE00279]</td> </tr> <tr> <td>EP2659994</td> <td>A3</td> <td>2014-10-01</td> <td>[EP2659994]</td> </tr> <tr> <td>US8932518</td> <td>B2</td> <td>2015-01-13</td> <td>[US8932518]</td> </tr> <tr> <td>US2015224566</td> <td>A1</td> <td>2015-08-13</td> <td>[US20150224566]</td> </tr> </table>		CA2806844	A1	2013-08-29	[CA2806844]	US2013224066	A1	2013-08-29	[US20130224066]	CN103286256	A	2013-09-11	[CN103286256]	JP2013180344	A	2013-09-12	[JP2013180344]	EP2659994	A2	2013-11-06	[EP2659994]	BR102013004515	A2	2014-04-22	[BR102013004515]	IN0279/DEL/2013	A	2014-08-08	[IN2013DE00279]	EP2659994	A3	2014-10-01	[EP2659994]	US8932518	B2	2015-01-13	[US8932518]	US2015224566	A1	2015-08-13	[US20150224566]
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- **Abstract:**

(EP2659994)

The disclosure relates generally to mold compositions and methods of molding and the articles so molded. More specifically, the disclosure relates to mold compositions, intrinsic facecoat (212) compositions, and methods for casting titanium-containing articles, and the titanium-containing articles so molded.


Claims

(EP2659994)

1. A mold for casting a titanium-containing article, comprising: a calcium aluminate cement (220) comprising calcium monoaluminate, calcium dialuminate, and mayenite, wherein said mold has an intrinsic facecoat (212) of about 10 microns to about 250 microns between the bulk of the mold (214) and the mold cavity (216).
2. The mold as recited in claim 1, wherein the mold comprises the bulk of the mold (214) and the intrinsic facecoat (212), and wherein the bulk of the mold and the intrinsic facecoat have different compositions and the intrinsic facecoat comprises calcium aluminate with a particle size of less than about 50 microns.
3. The mold as recited in either of claim 1 or claim 2, wherein the mold (214) comprises the bulk of the mold and the intrinsic facecoat (212), and wherein the bulk of the mold and the intrinsic facecoat have different compositions and wherein the bulk of the mold comprises alumina particles larger than about 50 microns.
4. The mold as recited in any preceding claim, wherein the mold comprises the bulk of the mold (214) and the intrinsic facecoat (212), and wherein the bulk of the mold comprises alumina particles larger than about 50 microns and the intrinsic facecoat comprises calcium aluminate particles less than about 50 microns in size.
5. The mold as recited in any preceding claim, the mold satisfying at least one of conditions (a) to (h): a) wherein the intrinsic facecoat (212) has, by weight fraction, at least 20 percent more calcium monoaluminate than does the bulk of the mold (214); b) wherein the intrinsic facecoat (212) has, by weight fraction, at least 20 per cent less alumina than does the bulk of the mold (214); c) wherein the intrinsic facecoat (212) has, by weight fraction, at least 20 per cent more calcium aluminate, at least 20 per cent less alumina, and at least 50 per cent less mayenite than does the bulk of the mold (214); d) wherein the weight fraction of calcium monoaluminate in the intrinsic facecoat (212) is more than 0.60 and the weight fraction of mayenite is less than 0.10; e) wherein said calcium monoaluminate in the bulk of the mold (214) comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the intrinsic facecoat (212) is about 0.10 to 0.90; f) wherein said calcium dialuminate in the bulk of the mold (214) comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat (212) is about 0.05 to 0.90; g) wherein said mayenite in the bulk of the mold (214) composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat (212) is about 0.001 to 0.05; and h) wherein said calcium monoaluminate in the bulk of the mold (214) comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the intrinsic facecoat (212) is about 0.1 to 0.9; said calcium dialuminate in the bulk of the mold (214) comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat is about 0.05 to 0.90; and wherein said mayenite in the bulk of the mold composition comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat is about 0.001 to 0.05.
6. The mold as recited in any preceding claim, further comprising aluminum oxide particles in the bulk of the mold (214) that are less than about 500 microns in outside dimension.
7. The mold as recited in any preceding claim, wherein the calcium aluminate cement comprises more than 30% by weight of the composition used to make the mold.
8. The mold as recited in any preceding claim, further comprising aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or compositions thereof.
9. The mold as recited in claim 8, wherein said aluminum oxide particles comprise from about 40 % by weight to about 68 % by weight of the composition used to make the mold.
10. A facecoat composition of a mold that is used for casting a titanium-containing article, said facecoat composition comprising: calcium monoaluminate, calcium dialuminate, and mayenite, wherein said facecoat composition is an intrinsic facecoat (212), is about 10 microns to about 250 microns thick, and is located between the bulk of the mold (214) and the surface of the mold that opens to the mold cavity (216).
11. The facecoat composition as recited in claim 10, wherein the intrinsic facecoat (212) has, by weight fraction, at least 20 percent more calcium aluminate, at least 20 percent less alumina, and at least 50 percent less mayenite than does the bulk of the mold (214).
12. The facecoat composition as recited in either of claim 10 or 11, wherein the weight fraction of calcium monoaluminate in the intrinsic facecoat (212) is more than 0.60 and the weight fraction of mayenite is less than 0.10.
13. The facecoat composition as recited in any of claims 10 to 12, wherein said calcium monoaluminate in the intrinsic facecoat (212) comprises a weight fraction of 0.10 to 0.90; said calcium dialuminate in the intrinsic facecoat comprises a weight fraction of 0.05 to 0.90; and wherein said mayenite in the intrinsic facecoat comprises a weight fraction of 0.001 to 0.05.
14. A method (700) for forming a mold for casting a titanium-containing article, said method comprising: combining (705) calcium aluminate with a liquid to produce a slurry of calcium aluminate, wherein the percentage of solids in the initial calcium aluminate / liquid mixture is about 70% to about 80% and the viscosity of the slurry is about 50 to about 150 centipoise; adding (707) oxide particles into the slurry such that the solids in the final calcium aluminate / liquid mixture with the large-scale oxide particles is about 75% to about 90%; introducing (710) the slurry into a mold cavity (218) that contains a fugitive pattern; and allowing the slurry to cure in the mold cavity to form a mold of a titanium-containing article.
15. A casting method (700) for titanium and titanium alloys comprising: obtaining (725) an investment casting mold composition comprising calcium aluminate and aluminum oxide, wherein the calcium aluminate is combined with a liquid to produce a slurry of calcium aluminate, and wherein the solids in the final calcium aluminate / liquid mixture with the large scale alumina is about 75% to about 90%; pouring (730) said investment casting mold composition into a vessel containing a fugitive pattern; curing (735) said investment casting mold composition; removing (740) said fugitive pattern from the mold; firing the mold; preheating (745) the mold to a mold casting temperature; pouring (750) molten titanium or titanium alloy into the heated mold; solidifying (760) the molten titanium or titanium alloy and forming a solidified titanium or titanium alloy casting; and removing the solidified titanium or titanium alloy casting from the mold.

Titanium aluminide intermetallic compositions

CA2810169

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor WEIMER MICHAEL JAMES BEWLAY BERNARD PATRICK GIGLIOTTI JR MICHAEL FRANCIS XAVIER KELLY THOMAS JOSEPH • International Patent Classification C22C C22C-001/00 C22C-001/02 C22C-014/00 C22C-021/00 C22C-030/00 C22F-001/18 C30B-029/52 F01D-005/14 F01D- 005/28 F02C-007/00 • US Patent Classification PCLO=416241000R PCLX=420418000 • CPC Code C22C-001/00; C22C-001/02/6; C22C-001/02; C22C-014/00; C22C-021/00; C22F-001/18/3 C22F-001/18/3; 	<ul style="list-style-type: none"> • Publication Information CA2810169 A1 2013-09-24 [CA2810169] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 2012US-13444357 2012-04-11 2012US-61615253 2012-03-24 																																
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2810169</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2013-09-24</td> <td style="width: 40%;">[CA2810169]</td> </tr> <tr> <td>CN103320648</td> <td>A</td> <td>2013-09-25</td> <td>[CN103320648]</td> </tr> <tr> <td>US2013251537</td> <td>A1</td> <td>2013-09-26</td> <td>[US20130251537]</td> </tr> <tr> <td>JP2013209750</td> <td>A</td> <td>2013-10-10</td> <td>[JP2013209750]</td> </tr> <tr> <td>EP2657358</td> <td>A1</td> <td>2013-10-30</td> <td>[EP2657358]</td> </tr> <tr> <td>IN0629/DEL/2013</td> <td>A</td> <td>2015-01-23</td> <td>[IN2013DE00629]</td> </tr> <tr> <td>BR102013006911</td> <td>A2</td> <td>2015-08-25</td> <td>[BR102013006911]</td> </tr> <tr> <td>EP2657358</td> <td>B1</td> <td>2015-09-09</td> <td>[EP2657358]</td> </tr> </table>		CA2810169	A1	2013-09-24	[CA2810169]	CN103320648	A	2013-09-25	[CN103320648]	US2013251537	A1	2013-09-26	[US20130251537]	JP2013209750	A	2013-10-10	[JP2013209750]	EP2657358	A1	2013-10-30	[EP2657358]	IN0629/DEL/2013	A	2015-01-23	[IN2013DE00629]	BR102013006911	A2	2015-08-25	[BR102013006911]	EP2657358	B1	2015-09-09	[EP2657358]
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- **Abstract:**
(EP2657358)
Gamma titanium aluminide intermetallic compositions (gamma TiAl intermetallics) based on the TiAl (gamma) intermetallic compound. The gamma TiAl intermetallics contain chromium and niobium, as well as controlled amounts of carbon that achieve a desirable balance in room temperature mechanical properties and high temperature creep capabilities at temperatures approaching and possibly exceeding 1600°F (about 870°C).

Claims

(EP2657358)

1. A titanium aluminide intermetallic composition based on a gamma TiAl intermetallic compound, the titanium aluminide intermetallic composition consisting of titanium and aluminum in amounts to yield the gamma TiAl intermetallic compound, chromium, niobium, carbon in an amount of 160 to 470 ppm, and incidental impurities.
2. The titanium aluminide intermetallic composition according to claim 1, wherein the titanium aluminide intermetallic composition contains, by atomic percent, about 46 to 50% aluminum.
3. The titanium aluminide intermetallic composition according to either of claim 1 or 2, wherein the titanium aluminide intermetallic composition contains about 160 to 420 ppm carbon.
4. The titanium aluminide intermetallic composition according to any of the preceding claims, wherein the titanium aluminide intermetallic composition contains about 270 to 420 ppm carbon.
5. The titanium aluminide intermetallic composition according to any of the preceding claims, wherein the titanium aluminide intermetallic composition contains about 300 ppm carbon.
6. The titanium aluminide intermetallic composition according to any of the preceding claims, wherein the titanium aluminide intermetallic composition is in the form of a casting and has a duplex microstructure containing equiaxed and lamellar morphologies after heat treatment.
7. The titanium aluminide intermetallic composition according to any of the preceding claims, wherein the titanium aluminide intermetallic composition exhibits a minimum room temperature ductility of not lower than 0.5%.
8. The titanium aluminide intermetallic composition according to any of the preceding claims, wherein the titanium aluminide intermetallic composition exhibits an average room temperature ductility of at least 1%.
9. A component formed of the titanium aluminide intermetallic of any of the preceding claims.
10. A titanium aluminide intermetallic composition based on a gamma TiAl intermetallic compound, the titanium aluminide intermetallic composition consisting of, by atomic percent, 1 to 3% chromium, 1 to 5% niobium, 160 to 470 ppm carbon, titanium and aluminum in amounts to yield the gamma TiAl intermetallic compound, and incidental impurities.
11. The titanium aluminide intermetallic composition according to claim 10, wherein the titanium aluminide intermetallic composition contains, by atomic percent, about 46 to 50% aluminum.
12. The titanium aluminide intermetallic composition according to either of claim 10 or 11, wherein the titanium aluminide intermetallic composition contains about 160 to 420 ppm carbon.
13. The titanium aluminide intermetallic composition according to any of claims 10 to 12, wherein the titanium aluminide intermetallic composition contains about 270 to 420 ppm carbon.
14. The titanium aluminide intermetallic composition according to any of claims 10 to 13, wherein the titanium aluminide intermetallic composition is in the form of a casting and has a duplex microstructure containing equiaxed and lamellar morphologies.
15. The titanium aluminide intermetallic composition according to any of claims 10 to 14, wherein the titanium aluminide intermetallic composition exhibits a minimum room temperature ductility of not lower than 0.5%.

Improved titanium aluminide alloys. CA2010672

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor ROWE RAYMOND GRANT • International Patent Classification C22C-014/00 C22C-021/00 C22C-027/02 C22C-030/00 F02C-007/00 • US Patent Classification PCLO=420418000 PCLX=420421000 PCLX=420426000 PCLX=420580000 • CPC Code C22C-014/00; C22C-027/02; F05B-2200/211 	<ul style="list-style-type: none"> • Publication Information CA2010672 A1 1990-09-20 [CA2010672] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1989US-07325738 1989-03-20 																																
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2010672</td> <td style="width: 10%;">A1</td> <td style="width: 20%;">1990-09-20</td> <td style="width: 40%;">[CA2010672]</td> </tr> <tr> <td>EP0388527</td> <td>A1</td> <td>1990-09-26</td> <td>[EP-388527]</td> </tr> <tr> <td>JPH02247345</td> <td>A</td> <td>1990-10-03</td> <td>[JP02247345]</td> </tr> <tr> <td>US5032357</td> <td>A</td> <td>1991-07-16</td> <td>[US5032357]</td> </tr> <tr> <td>EP0388527</td> <td>B1</td> <td>1994-06-22</td> <td>[EP-388527]</td> </tr> <tr> <td>DE68916414</td> <td>D1</td> <td>1994-07-28</td> <td>[DE68916414]</td> </tr> <tr> <td>DE68916414</td> <td>T2</td> <td>1995-02-16</td> <td>[DE68916414]</td> </tr> <tr> <td>JP3097748</td> <td>B2</td> <td>2000-10-10</td> <td>[JP3097748]</td> </tr> </table> 		CA2010672	A1	1990-09-20	[CA2010672]	EP0388527	A1	1990-09-26	[EP-388527]	JPH02247345	A	1990-10-03	[JP02247345]	US5032357	A	1991-07-16	[US5032357]	EP0388527	B1	1994-06-22	[EP-388527]	DE68916414	D1	1994-07-28	[DE68916414]	DE68916414	T2	1995-02-16	[DE68916414]	JP3097748	B2	2000-10-10	[JP3097748]
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- **Abstract:**

(EP-388527)

An improved titanium aluminide alloy contains from about 18 to 30 atomic percent aluminum, about 34 to 18 atomic percent niobium, with the balance titanium. In alloys of this invention a substantial portion of the microstructure, comprising at least about 50% of the volume fraction, is an orthorhombic phase.

Claims

(EP-388527)

1. A titanium aluminum alloy, comprising titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 1 with the niobium being at least 18 percent, said alloy having a high yield strength at temperatures up to at least 1500 DEG.F and good fracture toughness.
2. The titanium aluminum alloy of Claim 1 said alloy being forgeable at temperatures from 1700 DEG.F to 2000 DEG.F.
3. The titanium aluminum alloy of Claim 1 further characterized by an orthorhombic phase comprising at least about 50% of the volume fraction of all phases present in the microstructure of said alloys.
4. A titanium aluminum alloy, comprising titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 2 with the niobium being at least 18 percent, said alloy having a high yield strength at temperatures up to at least 1500 DEG.F and superior fracture toughness.
5. The titanium aluminum alloy of Claim 4 said alloy being forgeable at temperatures from 1700 DEG.F to 2000 DEG.F.
6. The titanium aluminum alloy of Claim 4 further characterized by an orthorhombic phase comprising at least about 50% of the volume fraction of all phases present in the microstructure of said alloy.
7. A titanium aluminum alloy, comprising titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 3 with the niobium being at least 18 percent said alloy having superior yield strength at temperatures up to at least 1500 DEG.F and good fracture toughness.
8. The titanium aluminum alloy of Claim 7 said alloy being forgeable at temperatures from 1700 DEG.F to 2000 DEG.F.
9. The titanium aluminum alloy of Claim 7 further characterized by an orthorhombic phase comprising at least about 50% of the volume fraction of all phases present in the microstructure of said alloy.
10. A titanium aluminum alloy, comprising titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 4 with the niobium being at least 18 percent;
said alloy having a superior combination of fracture toughness, and high yield strength at temperatures up to at least 1500 DEG.F.
11. The titanium aluminum alloy of Claim 10 said alloy being forgeable at temperatures from 1700 DEG.F to 2000 DEG.F.
12. The titanium aluminum alloy of Claim 10 further characterized by an orthorhombic phase comprising at least about 50% of the volume fraction of all phases present in the microstructure of said alloy.
13. A gas turbine engine component formed from an alloy, comprising titanium, aluminum, and niobium in the approximate atomic percentages shown as the hatched area in Figure 1.
14. The gas turbine engine component of Claim 13 wherein said alloy is comprised of titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 2.
15. The gas turbine engine component of Claim 13 wherein said alloy is comprised of titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 3.
16. The gas turbine engine component of Claim 13 wherein said alloy is comprised of titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 4.
17. Articles having high yield strength at elevated temperatures up to at least 1500 DEG.F and good fracture toughness formed from an alloy, comprising titanium, aluminum and niobium in the approximate atomic percentages shown as the hatched area in Figure 1.
18. The article of Claim 17 having high yield strength at elevated temperatures up to at least 1500 DEG.F and superior fracture toughness formed from said alloy wherein the titanium, aluminum and niobium are in the approximate atomic percentages shown as the hatched area in Figure 2.
19. The article of Claim 17 having superior strength at elevated temperatures up to at least 1500 DEG.F and good fracture toughness formed from said alloy wherein the titanium, aluminum and niobium are in the approximate atomic percentages shown as the hatched area in Figure 3.
20. The article of Claim 17 having a superior combination of fracture toughness, and high yield strength at temperatures up to at least 1500 DEG.F formed from said alloy wherein the titanium, aluminum and niobium are in the approximate atomic percentages shown as the hatched area in Figure 4.
21. A titanium aluminum alloy, comprising in atomic percent:
about 18 to 30 percent aluminum;
and
about 18 to 34 percent niobium with the balance essentially titanium;

said alloy having a high yield strength at temperatures up to at least 1500 DEG.F and good fracture toughness.
22. A titanium aluminum alloy, comprising in atomic percent:
about 18 to 25.5 percent aluminum;
and
about 20 to 34 percent niobium with the balance essentially titanium;

said alloy having a high yield strength at temperatures up to at least 1500 DEG.F and superior fracture toughness.
23. A titanium aluminum alloy, comprising in atomic percent:
about 23 to 30 percent aluminum;
and
about 18 to 28 percent niobium with the balance essentially titanium;


said alloy having a superior yield strength at temperatures up to at least 1500 DEG.F and good fracture toughness.

24. A titanium aluminum alloy, comprising in atomic percent:
about 21 to 26 percent aluminum;
and
about 19.5 to 28 percent niobium with the balance essentially titanium;

said alloy having a superior combination of fracture toughness, and high yield strength at temperatures up to at least 1500 DEG.F.

25. A gas turbine engine component formed from an alloy, comprising in atomic percent:
about 18 to 30 percent aluminum;
and
about 18 to 34 percent niobium with the balance essentially titanium.

Gamma titanium aluminide. US5213635

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-001/00 C22C-014/00 • US Patent Classification PCLO=148421000 PCLX=148670000 PCLX=420418000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5213635 A 1993-05-25 [US5213635] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1991US-07812393 1991-12-23 																												
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">US5213635</td> <td style="width: 10%;">A</td> <td style="width: 20%;">1993-05-25</td> <td style="width: 40%;">[US5213635]</td> </tr> <tr> <td>EP0549181</td> <td>A1</td> <td>1993-06-30</td> <td>[EP-549181]</td> </tr> <tr> <td>JPH05255783</td> <td>A</td> <td>1993-10-05</td> <td>[JP05255783]</td> </tr> <tr> <td>EP0549181</td> <td>B1</td> <td>1995-11-22</td> <td>[EP-549181]</td> </tr> <tr> <td>DE69206247</td> <td>D1</td> <td>1996-01-04</td> <td>[DE69206247]</td> </tr> <tr> <td>DE69206247</td> <td>T2</td> <td>1996-07-04</td> <td>[DE69206247]</td> </tr> <tr> <td>JP2686212</td> <td>B2</td> <td>1997-12-08</td> <td>[JP2686212]</td> </tr> </table> 		US5213635	A	1993-05-25	[US5213635]	EP0549181	A1	1993-06-30	[EP-549181]	JPH05255783	A	1993-10-05	[JP05255783]	EP0549181	B1	1995-11-22	[EP-549181]	DE69206247	D1	1996-01-04	[DE69206247]	DE69206247	T2	1996-07-04	[DE69206247]	JP2686212	B2	1997-12-08	[JP2686212]
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- **Abstract:**

(EP-549181)

A method for providing improved castability in a gamma titanium aluminide is taught. The method involves adding inclusions to the near stoichiometric titanium aluminide and specifically low chromium and high niobium inclusions. Niobium additions are made in concentrations between 6 and 14 atomic percent. Chromium additions are between 1 and 3 atom percent. Property improvements are also achieved. A preferred composition is according to the following expression: Ti-Al46-48 Cr1-3 Nb6-14 . (see diagramm 1 page 0)

Claims

(EP-549181)

1. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 6 - 4 8 Cr1 - 3 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

2. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 8 Cr1 - 3 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

3. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 6 - 4 8 Cr2 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

4. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 6 - 4 8 Cr2 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.

5. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 8 Cr1 - 3 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.

6. A castable composition comprising titanium, aluminum, chromium, and niobium in the following approximate composition:

Ti-Al4 8 Cr2 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.

7. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 6 - 4 8 Cr1 - 3 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

8. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 8 Cr1 - 3 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

9. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 6 - 4 8 Cr2 Nb6 - 1 4 .

said alloy having been prepared by cast and HIP processing.

10. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 6 - 4 8 Cr2 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.

11. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 8 Cr1 - 3 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.





12. A structural element, said element being a casting of a composition having the following approximate composition:

Ti-Al4 8 Cr2 Nb8 - 1 2 .

said alloy having been prepared by cast and HIP processing.

Calcium hexaluminate-containing mold and facecoat compositions and methods for casting titanium and titanium aluminide alloys

US20140209268

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK ELLIS BRIAN MICHAEL BANCHERI STEPHEN FRANCIS WEIMER MICHAEL JAMES MCKIEVER JOAN • International Patent Classification B22C-001/00 B22C-001/18 B22C-009/04 B22C-009/24 B22D-021/06 • US Patent Classification PCLO=164529000 PCLX=249114100 PCLX=249134000 PCLX=428328000 PCLX=428332000 • CPC Code B22C-001/00; B22C-001/18; B22C-009/04; B22D-021/00/5 B22D-021/00/5; Y10T-428/256; Y10T-428/26 	<ul style="list-style-type: none"> • Publication Information US2014209268 A1 2014-07-31 [US20140209268]     • Priority Details 2013US-13752880 2013-01-29 2014WO-US12301 2014-01-21 																												
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">US2014209268</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">2014-07-31</td> <td style="width: 30%;">[US20140209268]</td> </tr> <tr> <td>CA2898454</td> <td>A1</td> <td>2014-08-07</td> <td>[CA2898454]</td> </tr> <tr> <td>WO2014120512</td> <td>A2</td> <td>2014-08-07</td> <td>[WO2014120512]</td> </tr> <tr> <td>WO2014120512</td> <td>A3</td> <td>2014-11-06</td> <td>[WO2014120512]</td> </tr> <tr> <td>CN104968451</td> <td>A</td> <td>2015-10-07</td> <td>[CN104968451]</td> </tr> <tr> <td>EP2950943</td> <td>A2</td> <td>2015-12-09</td> <td>[EP2950943]</td> </tr> <tr> <td>JP2016504202</td> <td>A</td> <td>2016-02-12</td> <td>[JP2016504202]</td> </tr> </table> 		US2014209268	A1	2014-07-31	[US20140209268]	CA2898454	A1	2014-08-07	[CA2898454]	WO2014120512	A2	2014-08-07	[WO2014120512]	WO2014120512	A3	2014-11-06	[WO2014120512]	CN104968451	A	2015-10-07	[CN104968451]	EP2950943	A2	2015-12-09	[EP2950943]	JP2016504202	A	2016-02-12	[JP2016504202]
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- **Abstract:**

(US20140209268)

The disclosure relates generally to mold compositions and methods of molding and the articles so molded. More specifically, the disclosure relates to mold compositions, intrinsic facecoat compositions, and methods for casting titanium-containing articles, and the titanium-containing articles so molded, where the mold comprises calcium hexaluminate.

(From US2014209268 A1)

Claims

(US20140209268)

1. A mold for casting a titanium-containing article, comprising: a bulk comprising calcium hexaluminate and a calcium aluminate cement, said calcium aluminate cement comprising calcium monoaluminate, calcium dialuminate, and mayenite; and

a cavity for casting a titanium-containing article therein.

2. The mold as recited in claim 1, wherein said calcium hexaluminate comprises particles that are less than about 50 microns in outside dimension.

3. The mold as recited in claim 1, wherein said calcium hexaluminate comprises from about 15 percent by weight to about 50 percent by weight of the mold.

4. The mold as recited in claim 1 further comprising: an intrinsic facecoat that is disposed about 10 microns to about 500 microns between the bulk and the cavity, wherein said intrinsic facecoat comprises calcium hexaluminate and a calcium aluminate cement, said calcium aluminate cement comprising calcium monoaluminate, calcium dialuminate, and mayenite.

5. The mold as recited in claim 4, wherein the intrinsic facecoat is a continuous intrinsic facecoat or a non-continuous intrinsic facecoat.

6. The mold as recited in claim 4, wherein the bulk and the intrinsic facecoat have different compositions, and wherein the intrinsic facecoat comprises calcium aluminate cement with a particle size of less than about 50 microns.

7. The mold as recited in claim 4, wherein the bulk and the intrinsic facecoat have different compositions, and wherein the bulk comprises alumina particles larger than about 50 microns.

8. The mold as recited in claim 4, wherein the bulk comprises alumina particles larger than about 50 microns and the intrinsic facecoat comprises calcium aluminate cement particles less than about 50 microns in size.

9. The mold as recited in claim 4, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate than does the bulk.

10. The mold as recited in claim 4, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent less alumina than does the bulk.

11. The mold as recited in claim 4, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate, at least 20 percent less alumina, and at least 50 percent less mayenite than does the bulk of the mold.

12. The mold as recited in claim 4, wherein said calcium monoaluminate in the bulk comprises a weight fraction of about 0.05 to 0.95, and said calcium monoaluminate in the intrinsic facecoat comprises a weight fraction of about 0.30 to 0.95.

13. The mold as recited in claim 4, wherein said calcium dialuminate in the bulk comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat comprises a weight fraction of about 0.05 to 0.30.

14. The mold as recited in claim 4, wherein said mayenite in the bulk comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat comprises a weight fraction of about 0.01 to 0.05.

15. The mold as recited in claim 4, wherein said calcium monoaluminate in the bulk comprises a weight fraction of about 0.05 to about 0.95, and said calcium monoaluminate in the intrinsic facecoat comprises a weight fraction of about 0.3 to about 0.95; wherein said calcium dialuminate in the bulk comprises a weight fraction of about 0.05 to about 0.80, and said calcium dialuminate in the intrinsic facecoat comprises a weight fraction of about 0.05 to about 0.30; and

wherein said mayenite in the bulk comprises a weight fraction of about 0.01 to about 0.30, and said mayenite in the intrinsic facecoat comprises a weight fraction of about 0.01 to about 0.05.

16. The mold as recited in claim 1 further comprising: aluminum oxide particles in the bulk that are less than about 500 microns in outside dimension.

17. The mold as recited in claim 1, wherein the calcium aluminate cement comprises more than 30 percent by weight of the composition used to make the mold.

18. The mold as recited in claim 1, further comprising: magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, or compositions thereof.

19. The mold as recited in claim 1, further comprising: hollow particles of aluminum oxide in the bulk.

20. The mold as recited in claim 18, further comprising: more than about 10 percent by weight and less than about 50 percent by weight of calcium oxide.

21. The mold as recited in claim 1, further comprising silica.

22. The mold as recited in claim 1, further comprising silicates in an amount of less than about 5 weight percent.

23. A facecoat of a mold that is used for casting a titanium-containing article, said facecoat, comprising: calcium hexaluminate, calcium monoaluminate, calcium dialuminate, and mayenite, wherein said facecoat is an intrinsic facecoat, is about 10 microns to about 500 microns thick, and is located between the bulk of the mold and the surface of the mold that opens to the mold cavity.

24. The facecoat as recited in claim 23, wherein said calcium hexaluminate comprises particles that are less than about 50 microns in outside dimension.

25. The facecoat as recited in claim 23, wherein the facecoat comprises calcium aluminate cement with a particle size of less than about 50 microns.

26. The facecoat as recited in claim 23, wherein the intrinsic facecoat has, by weight fraction, at least 20 percent more calcium monoaluminate, at least 20 percent less alumina, and at least 50 percent less mayenite than does the bulk of the mold.

27. The facecoat as recited in claim 23, wherein the weight fraction of calcium monoaluminate in the intrinsic facecoat is more than 0.30 and the weight fraction of mayenite is less than 0.10.

28. The facecoat as recited in claim 23, wherein said calcium hexaluminate in the intrinsic facecoat comprises a weight fraction of 0.01 to 0.20; said calcium monoaluminate in the intrinsic facecoat comprises a weight fraction of 0.30 to 0.95; said calcium dialuminate in the intrinsic facecoat comprises a weight fraction of 0.05 to 0.30; and wherein said mayenite in the intrinsic facecoat comprises a weight fraction of 0.01 to 0.05.

29. The facecoat as recited in claim 23, wherein the facecoat further comprises silica.

30. A method for forming a mold for casting a titanium-containing article, said method comprising: providing an initial slurry of a calcium hexaluminate-calcium aluminate cement mixture, wherein the percentage of solids in the initial slurry is about 65% to about 80% and the viscosity of the initial slurry is about 30 to about 300 centipoise;

adding large-scale oxide particles into the initial slurry to yield a final slurry comprising the calcium hexaluminate-calcium aluminate cement mixture with the large-scale oxide particles such that the percentage of solids in the final slurry is about 75% to about 95%;

introducing the final slurry into a mold cavity that contains a fugitive pattern; and

allowing the final slurry to cure in the mold cavity to form a mold for casting a titanium-containing article.

31. The method as recited in claim 30, wherein providing the initial slurry comprises: combining calcium hexaluminate and calcium aluminate cement with a liquid to produce an initial slurry of a calcium hexaluminate-calcium aluminate cement mixture, wherein the percentage of solids in the initial slurry is about 65% to about 80% and the viscosity of the initial slurry is about 30 to about 300 centipoise.

32. The method as recited in claim 30, wherein providing the initial slurry comprises: combining calcium hexaluminate and calcium aluminate cement with a liquid to produce a pre-initial slurry of a calcium hexaluminate-calcium aluminate cement mixture, wherein the percentage of solids in the pre-initial slurry is about 41% to about 65%; and

adding more calcium hexaluminate, calcium aluminate cement, and/or liquid to the pre-initial slurry to yield the initial slurry having a percentage of solids of about 65% to about 80% and a viscosity of about 30 to about 300 centipoise.

33. A casting method for titanium and titanium alloys, comprising: obtaining an investment casting mold composition comprising calcium hexaluminate, calcium aluminate cement, and aluminum oxide, said investment casting mold composition being produced by: combining calcium hexaluminate and calcium aluminate cement with a liquid to produce an initial slurry of a calcium hexaluminate-calcium aluminate cement mixture having a percentage of solids of about 65% to about 80% and

adding large-scale aluminum oxide particles into the initial slurry to yield a final slurry comprising the calcium hexaluminate-calcium aluminate cement mixture with the large-scale aluminum oxide particles such that the percentage of solids in the final slurry is about 75% to about 95%;

pouring said investment casting mold composition into a vessel containing a fugitive pattern;

curing said investment casting mold composition;

removing said fugitive pattern from the mold;

firing the mold;


preheating the mold to a mold casting temperature;

pouring molten titanium or titanium alloy into the heated mold;

solidifying the molten titanium or titanium alloy and forming a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.

Methods for processing titanium aluminide intermetallic compositions CA2809444

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor KELLY THOMAS JOSEPH BEWLAY BERNARD PATRICK WEIMER MICHAEL JAMES WHITACRE RICHARD KENNETH • International Patent Classification C22C C22C-014/00 C22C-021/00 C22C-030/00 C22F-001/00 C22F-001/18 • US Patent Classification PCLO=148707000 • CPC Code C22C-001/02; C22C-014/00; C22F-001/18/3 C22F-001/18; 	<ul style="list-style-type: none"> • Publication Information CA2809444 A1 2013-09-23 [CA2809444] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 2012US-13459420 2012-04-30 2012US-61614751 2012-03-23 2013EP-0159885 2013-03-19 																																								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2809444</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2013-09-23</td> <td style="width: 40%;">[CA2809444]</td> </tr> <tr> <td>CN103320647</td> <td>A</td> <td>2013-09-25</td> <td>[CN103320647]</td> </tr> <tr> <td>EP2641984</td> <td>A2</td> <td>2013-09-25</td> <td>[EP2641984]</td> </tr> <tr> <td>US2013248061</td> <td>A1</td> <td>2013-09-26</td> <td>[US20130248061]</td> </tr> <tr> <td>JP2013199705</td> <td>A</td> <td>2013-10-03</td> <td>[JP2013199705]</td> </tr> <tr> <td>EP2641984</td> <td>A3</td> <td>2014-03-12</td> <td>[EP2641984]</td> </tr> <tr> <td>IN0411/DEL/2013</td> <td>A</td> <td>2015-01-16</td> <td>[IN2013DE00411]</td> </tr> <tr> <td>BR102013006917</td> <td>A2</td> <td>2015-07-07</td> <td>[BR102013006917]</td> </tr> <tr> <td>EP2641984</td> <td>B1</td> <td>2015-10-21</td> <td>[EP2641984]</td> </tr> <tr> <td>EP2995695</td> <td>A1</td> <td>2016-03-16</td> <td>[EP2995695]</td> </tr> </table> 		CA2809444	A1	2013-09-23	[CA2809444]	CN103320647	A	2013-09-25	[CN103320647]	EP2641984	A2	2013-09-25	[EP2641984]	US2013248061	A1	2013-09-26	[US20130248061]	JP2013199705	A	2013-10-03	[JP2013199705]	EP2641984	A3	2014-03-12	[EP2641984]	IN0411/DEL/2013	A	2015-01-16	[IN2013DE00411]	BR102013006917	A2	2015-07-07	[BR102013006917]	EP2641984	B1	2015-10-21	[EP2641984]	EP2995695	A1	2016-03-16	[EP2995695]
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- **Abstract:**

(EP2641984)

Methods of processing compositions containing titanium and aluminum, especially titanium aluminide intermetallic compositions (TiAl intermetallics) based on the TiAl (gamma) intermetallic compound. The methods entail processing steps that include a hot isostatic pressing (HIP) cycle and a heat treatment cycle that can be performed in a single vessel. TiAl intermetallic compositions processed in this manner preferably exhibit a duplex microstructure containing equiaxed and lamellar morphologies.


Claims

(EP2641984)

1. A method of processing a titanium aluminide intermetallic composition based on a TiAl intermetallic compound to yield a duplex microstructure containing equiaxed and lamellar morphologies of the gamma TiAl phase, the method comprising: hot isostatic pressing the titanium aluminide intermetallic composition at a temperature of at least 1260 deg.C; cooling the titanium aluminide intermetallic composition to a temperature of not less than 1120 deg.C; heat treating the titanium aluminide intermetallic composition at a temperature of about 1150 to about 1200 deg.C; and then cooling the titanium aluminide intermetallic composition to room temperature; wherein the titanium aluminide intermetallic composition exhibits the duplex microstructure following the step of cooling the titanium aluminide intermetallic composition to room temperature.
2. The method according to claim 1, wherein the hot isostatic pressing step is conducted at a pressure of at least 1030 bar.
3. The method according to any of the preceding claims, wherein the hot isostatic pressing step is conducted at a temperature of at least 1290 deg.C.
4. The method according to either of claim 1 or 2, wherein the hot isostatic pressing step is conducted at a temperature of about 1300 to about 1330 deg.C.
5. The method according to any of the preceding claims, wherein the hot isostatic pressing step is conducted for a duration of about 2.5 to about 5 hours.
6. The method according to any of the preceding claims, wherein the titanium aluminide intermetallic composition is cooled to a temperature of not less than 1150 deg.C during the cooling step.
7. The method according to claim 6, wherein the titanium aluminide intermetallic composition is cooled to a temperature of 1150 to about 1175 deg.C during the cooling step.
8. The method according to any of the preceding claims, wherein the heat treatment step is performed at a temperature of about 1150 to about 1175 deg.C.
9. The method according to any of the preceding claims, wherein the titanium aluminide intermetallic composition consists of titanium and aluminum in amounts to yield the TiAl intermetallic compound, one or more of chromium, niobium and tantalum, and incidental impurities.
10. The method according to any of the preceding claims, wherein the titanium aluminide intermetallic composition consists of, by atomic percent, about 1.8 to about 2% chromium, up to about 2% niobium, up to about 4% tantalum, titanium and aluminum in amounts to yield the TiAl intermetallic compound, and incidental impurities.
11. The method according to claim 10, wherein the titanium aluminide intermetallic composition contains about 46.7 to 48.9 atomic percent titanium.
12. The method according to either of claim 10 or 11, wherein the titanium aluminide intermetallic composition contains about 47.3 atomic percent aluminum.
13. The method according to any of claims 10 to 12, wherein the titanium aluminide intermetallic composition contains, in atomic percent, about 1.9% chromium, about 1.9 atomic percent niobium, and no intentional amount of tantalum.
14. The method according to any of claims 10 to 12, wherein the titanium aluminide intermetallic composition contains, in atomic percent, about 1.8% chromium, about 0.85 atomic percent niobium, and about 1.7% tantalum.
15. The method according to any of claims 10 to 12, wherein the titanium aluminide intermetallic composition contains, in atomic percent, about 2% chromium, about 4% tantalum, and no intentional amount of niobium.
16. A method of processing a titanium aluminide intermetallic composition based on a TiAl intermetallic compound to yield a duplex microstructure containing equiaxed and lamellar morphologies of the gamma TiAl phase, the method comprising: hot isostatic pressing the titanium aluminide intermetallic composition; cooling the titanium aluminide intermetallic composition; heat treating the titanium aluminide intermetallic composition at a temperature of at least 1260 deg.C for about 2.5 to about 5 hours; cooling the titanium aluminide intermetallic composition to a temperature of not less than 1120 deg.C; holding the titanium aluminide intermetallic composition at a hold temperature of about 1150 to about 1200 deg.C for a duration of about two to about six hours; and then cooling the titanium aluminide intermetallic composition to room temperature; wherein the titanium aluminide intermetallic composition exhibits the duplex microstructure following the step of cooling the titanium aluminide intermetallic composition to room temperature.

Titanium aluminide articles with improved surface finish and methods for their manufacture

CA2848838

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor KNUDSEN BRUCE BEWLAY BERNARD PATRICK • International Patent Classification B24B-001/00 B24B-019/14 B32B-003/00 C22C-014/00 C22C-021/00 C22F-001/18 F01D-005/14 F01D-005/28 F01D-025/00 F02C-007/00 • US Patent Classification PCLO=416241000R PCLX=428195100 PCLX=451028000 • CPC Code B24B-001/00; B24B-019/14; B24B-021/16/5; C21D-007/04; C22F-001/18/3; F01D-005/28/6; F01D-005/28; F05D-2300/182; F05D-2300/516; Y02T-050/672; Y02T-050/673 Y02T-050/673; Y10T-428/24802 Y10T-428/24802; 	<ul style="list-style-type: none"> • Publication Information CA2848838 A1 2013-04-04 [CA2848838]  <ul style="list-style-type: none"> • Priority Details 2011US-13250231 2011-09-30 2012WO-US53297 2012-08-31 																												
<ul style="list-style-type: none"> • Fampat family <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">CA2848838</td> <td style="width: 15%;">A1</td> <td style="width: 15%;">2013-04-04</td> <td style="width: 40%;">[CA2848838]</td> </tr> <tr> <td>WO2013048670</td> <td>A1</td> <td>2013-04-04</td> <td>[WO201348670]</td> </tr> <tr> <td>US2013084190</td> <td>A1</td> <td>2013-04-04</td> <td>[US20130084190]</td> </tr> <tr> <td>CN103826799</td> <td>A</td> <td>2014-05-28</td> <td>[CN103826799]</td> </tr> <tr> <td>EP2760632</td> <td>A1</td> <td>2014-08-06</td> <td>[EP2760632]</td> </tr> <tr> <td>IN2327/CHENP/2014</td> <td>A</td> <td>2014-10-10</td> <td>[IN2014CN02327]</td> </tr> <tr> <td>JP2015501224</td> <td>A</td> <td>2015-01-15</td> <td>[JP2015501224]</td> </tr> </table>		CA2848838	A1	2013-04-04	[CA2848838]	WO2013048670	A1	2013-04-04	[WO201348670]	US2013084190	A1	2013-04-04	[US20130084190]	CN103826799	A	2014-05-28	[CN103826799]	EP2760632	A1	2014-08-06	[EP2760632]	IN2327/CHENP/2014	A	2014-10-10	[IN2014CN02327]	JP2015501224	A	2015-01-15	[JP2015501224]
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- **Abstract:**

(US20130084190)

Titanium-containing articles having improved surface finishes and methods for improving surface finishes on titanium containing articles are provided. One method includes passing an abrasive medium across a surface of a titanium aluminide alloy-containing article, for example, a turbine blade, at high linear speed; deforming the surface of the titanium aluminide alloy-containing article with the abrasive medium and reducing a surface roughness of the surface of the titanium aluminide alloy-containing article and improving the surface finish of the surface. Surface finishes of 20 microinches Ra or less can be obtained. Though aspects of the invention can be used in fabricating high performance turbine blades, the methods disclosed can be applied to the treatment of any titanium-containing article for which it is difficult to obtain an improved surface finish. (From US2013084190 A1)

Claims

(US20130084190)

1. A method for improving the surface finish of a titanium aluminide alloy-containing article, said method comprising: providing a titanium aluminide alloy-containing article;

passing an abrasive medium across a surface of said titanium aluminide alloy-containing article at high linear speed;

deforming the surface of the titanium aluminide alloy-containing article; and

reducing the surface roughness of the titanium aluminide alloy-containing article, thereby improving the surface finish of the article.

2. The method as recited in claim 1, wherein passing the abrasive medium across the surface of the article comprises interacting the abrasive medium with the titanium aluminide microstructure.

3. The method as recited in claim 1, wherein deforming the surface comprises plastically deforming the titanium aluminide alloy.

4. The method as recited in claim 3, wherein the titanium aluminide alloy comprises a gamma titanium aluminide phase and an alpha 2 (Ti₃Al) phase.

5. The method as recited in claim 1, wherein the roughness of the surface of the article is reduced by at least about 50%.

6. The method as recited in claim 1, wherein the titanium aluminide alloy-containing article comprises a titanium aluminide alloy-containing turbine blade.

7. The method as recited in claim 1, wherein the abrasive medium comprises alumina, garnet, silica, silicon carbide, boron carbide, diamond, tungsten carbide, and compositions thereof.

8. The method as recited in claim 1, wherein said passing comprises passing a first abrasive medium of particles ranging from about 140 microns to about 195 microns across the surface, then passing a second abrasive medium of particles ranging from about 115 microns to about 145 microns across the surface, and then passing a third abrasive medium of particles ranging from about 40 microns to about 60 microns across the surface.

9. The method as recited in claim 1, wherein said deforming step comprises heating the surface to a temperature above the ductile brittle transition temperature of the titanium aluminide alloy.

10. A method for improving a surface finish of a titanium aluminide alloy-containing article, said method comprising: stabilizing the titanium aluminide alloy-containing article on a structure;

passing an abrasive medium across a surface of said stabilized titanium aluminide alloy-article at high linear speed; and

deforming both a gamma titanium aluminide phase and an alpha 2 (Ti₃Al) phase of the titanium aluminide alloy, wherein the surface finish of the titanium aluminide alloy-containing article is improved.

11. The method as recited in claim 10, wherein the titanium aluminide alloy-containing article comprises a titanium aluminide alloy-containing turbine blade.

12. The method as recited in claim 10, wherein the roughness of the surface of the article is reduced by at least about 50%.

13. The method as recited in claim 10, wherein the abrasive medium comprises alumina, garnet, silica, silicon carbide, boron carbide, diamond, tungsten carbide, and compositions thereof.

14. The method as recited in claim 10, wherein said passing comprises passing a first abrasive medium of particles ranging from about 140 microns to about 195 microns across the surface, then passing a second abrasive medium of particles ranging from about 115 microns to about 145 microns across the surface, and then passing a third abrasive medium of particles ranging from about 40 microns to about 60 microns across the surface.

15. The method as recited in claim 10, wherein said deforming step comprises heating the surface to a temperature above the ductile brittle transition temperature of the titanium aluminide alloy.

16. A method for reducing the Ra value of the surface roughness of a titanium aluminide alloy-containing article, said method comprising: stabilizing the titanium aluminide alloy on a structure;

passing sequentially decreasing grit sizes across the surface of said stabilized titanium aluminide alloy at high speeds; and

deforming both the gamma TiAl phase and the alpha 2 (Ti₃Al) phase of the titanium aluminide alloy plastically, and thereby reducing the Ra value of the surface of the titanium aluminide alloy.

17. The method as recited in claim 16, wherein the titanium aluminide alloy-containing article comprises a titanium aluminide alloy-containing turbine blade.

18. The method as recited in claim 16, wherein the roughness of the surface of the article is reduced at least about 50%.

19. The method as recited in claim 16, wherein the roughness of the surface of the article is reduced to about 20 Ra or less.

20. The method as recited in claim 16, wherein the abrasive medium comprises at least one of alumina, garnet, silica, silicon carbide, boron carbide, diamond, tungsten carbide, and compositions thereof.

21. The method as recited in claim 16, wherein said passing comprises passing a first abrasive medium of particles ranging from about 140 microns to about 195 microns across the surface, then passing a second abrasive medium of particles ranging from about 115 microns to about 145 microns across the surface, and then passing a third abrasive medium of particles ranging from about 40 microns to about 60 microns across the surface.

22. The method as recited in claim 16, wherein said deforming step comprises heating the surface to a temperature above the ductile brittle transition temperature of the titanium aluminide alloy.

23. The method as recited in claim 16, wherein after treatment the Ra value is reduced by a factor of about three to about six.

24. A titanium aluminide alloy-containing article having a roughness of less than about one micron across at least a portion of a surface containing titanium aluminide alloy.

25. The article as recited in claim 24, wherein said article is an investment cast article.


26. The article as recited in claim 24, wherein said article is a turbine blade.

27. The article as recited in claim 24, wherein said article is a turbine blade and wherein at least a portion of a working surface of the turbine blade has a roughness of less than about one micron.

28. The article as recited in claim 24, wherein the majority of the surface area of the titanium aluminide alloy article is substantially planar and has a roughness of less than about one micron.

29. The article as recited in claim 24, wherein said article is a turbine engine blade having an average roughness of less than 15 Ra across at least a portion of the working surface of the blade.

Repair of gamma titanium aluminide articles US5873703

<ul style="list-style-type: none">• Patent Assignee GENERAL ELECTRIC• Inventor KELLY THOMAS J SMASHEY RUSSELL W BOERGER ERIC J SHERANKO RONALD L• International Patent Classification B23K-001/00 B23K-001/19 B23K-020/02 B23K-035/00 B23K-035/32 F01D-005/00 F01D-005/28• US Patent Classification PCLO=416241000R PCLX=029402160 PCLX=029889100 PCLX=228119000 PCLX=228215000 PCLX=228232000 PCLX=228233200 PCLX=228262720 PCLX=415200000 PCLX=416213000R• CPC Code B23K-001/00/18; B23K-001/19; B23K-020/02/1; B23K-035/00/5; B23K-035/32/5; B23P-006/00/7; B23P-006/04/5; F01D-005/00/5; F01D-005/28/8; Y10T-029/49318; Y10T-029/49742	<ul style="list-style-type: none">• Publication Information US5873703 A 1999-02-23 [US5873703] • Priority Details 1997US-08785401 1997-01-22
<ul style="list-style-type: none">• Fampat family US5873703 A 1999-02-23 [US5873703]	

- **Abstract:**

(US5873703)

A surface defect in a gamma titanium aluminide article is repaired by weld repairing the defect and thereafter sealing the surface-connected cracks in the weldment. The surface-connected cracks are repaired by applying to the region of the weldment a powder of a brazing filler metal that is compatible with the gamma titanium aluminide alloy and with the weldment, and thereafter heating the article to a brazing temperature above the liquidus of the brazing filler metal. The article is preferably hot isostatically pressed after the repair is completed to close internal defects that cannot otherwise be closed due to the surface connected cracks.

Claims

(US5873703)

What is claimed is:

13.

A gamma titanium aluminide article, comprising:

a body made of a gamma titanium aluminide alloy, the body having a repaired area therein;

a weldment of a welding filler metal within the repaired area, the weldment having surface-connected weld defects therein;

and
a brazing filler metal within the surface-connected weld defects and bonded to the weldment, the brazing filler metal being chemically compatible with the gamma titanium aluminide alloy and with the welding filler metal.

14. The article of claim 13, wherein the body is a component of a gas turbine engine.

1. A method of repairing a gamma titanium aluminide article, comprising the steps of:

providing the article of the gamma titanium aluminide alloy having a defect in a surface thereof;

repairing the defect by welding using a weldment of a welding filler metal, the step of repairing leaving surface-connected cracks in a surface of the weldment;

selecting a brazing filler metal that is chemically compatible with the gamma titanium aluminide alloy and the welding filler metal;

applying the brazing filler metal to the surface of the weldment;

heating the article to a brazing temperature at which the brazing filler metal is molten;

and

cooling the article to ambient temperature, whereat the brazing filler metal is present in and fills the surface-connected cracks in the weldment.

2. The method of claim 1, wherein the step of providing the article includes the step of providing the article having the shape of a component of a gas turbine engine.

3. The method of claim 1, wherein the step of providing the article includes the step of providing the article having a composition, in atomic percent, selected from the group consisting of 48 percent aluminum, 2 percent chromium, 2 percent niobium, balance titanium and minor amounts of impurities totalling 100 atomic percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totaling 100 atomic percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totalling 100 atomic percent, plus 0.8 volume percent titanium diboride (TiB₂);

47 percent aluminum, 5 percent niobium, 1 percent tungsten, balance titanium and minor amounts of impurities totalling 100 atomic percent;

and 47 percent aluminum, 1 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totalling 100 atomic percent.

4. The method of claim 1, wherein the step of repairing includes the step of repairing the defect by gas tungsten the welding.

5. The method of claim 1, wherein the step of repairing includes the step of providing the welding filler metal of about the same composition as the gamma titanium aluminide alloy.

6. The method of claim 1, wherein the step of selecting the brazing filler metal includes the step of selecting the brazing filler metal having a composition, in weight percent, of about 70 percent titanium, about 15 percent copper, and about 15 percent nickel.

7. The method of claim 1, wherein the step of applying includes the step of providing a powder of the brazing filler metal.

8. The method of claim 1, wherein the step of heating includes the steps of heating the article to a soaking temperature of no more than a solidus temperature of the brazing filler metal and holding the article at the soaking temperature for a period of time sufficient to permit the article to reach thermal equilibrium at the soaking temperature, and thereafter

heating the article to a temperature of above the solidus temperature.

9. The method of claim 1, including the additional steps, after the step of repairing and prior to the step of applying, of cleaning the surface of the weldment, and

heating the article to a temperature of at least about 1800 (degree) F. and no greater than about 2200 (degree) F.

10. The method of claim 1, including an additional step, prior to the step of heating, of placing a stop-off medium around a region of the surface-connected cracks.

11. The method of claim 1, including an additional step, after the step of heating, of hot isostatically pressing the article, and wherein there has been no hot isostatic pressing step prior thereto.

12. A gamma titanium aluminide article prepared by the method of claim 1.

15. The article of claim 13, wherein the article has a composition, in atomic percent, selected from the group consisting of 48 percent aluminum, 2 percent chromium, 2 percent niobium, balance titanium and minor amounts of impurities totalling 100 atomic percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totaling 100 atomic percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totalling 100 atomic percent, plus 0.8 volume percent titanium diboride (TiB₂);

47 percent aluminum, 5 percent niobium, 1 percent tungsten, balance titanium and minor amounts of impurities totalling 100 atomic percent;

and 47 percent aluminum, 1 percent manganese, 2 percent niobium, balance titanium and minor amounts of impurities totalling

100 atomic percent.


16. The article of claim 13, wherein the welding filler metal has about the same composition as the gamma titanium aluminide alloy.

17. The article of claim 13, wherein the brazing filler metal has a composition, in weight percent of about 70 percent titanium, about 15 percent copper, and about 15 percent nickel.

18. The article of claim 13, wherein the article has substantially no internal porosity and shrinkage therein.

Low-porosity gamma titanium aluminide cast articles and their preparation

US5823243

<ul style="list-style-type: none"> • <u>Patent Assignee</u> GE AIRCRAFT ENGINES GENERAL ELECTRIC • <u>Inventor</u> KELLY THOMAS J • <u>International Patent Classification</u> B22D-027/20 • <u>US Patent Classification</u> PCLO=164057100 PCLX=164516000 • <u>CPC Code</u> B22D-027/20 	<ul style="list-style-type: none"> • <u>Publication Information</u> US5823243 A 1998-10-20 [US5823243] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • <u>Priority Details</u> 1996US-08775700 1996-12-31
<ul style="list-style-type: none"> • <u>Fampat family</u> US5823243 A 1998-10-20 [US5823243] 	

- **Abstract:**

(US5823243)

The inside surface of the mold used to cast gamma titanium aluminide articles is pretreated with a facecoating of an inoculant such as titanium diboride or titanium carbide. When the molten metal of the composition that produces the gamma titanium aluminide is cast into the mold, the facecoating nucleates grains at the surface of the casting, which inhibits the formation of surface-connected porosity in the casting. Subsequent hot isostatic pressing of the article produces a sounder article than otherwise could be achieved.

Claims

(US5823243)

What is claimed is:

1.

A method of preparing a gamma titanium aluminide article, comprising the steps of:

furnishing a mold having an inner surface defining the shape of an article, at least a portion of the inner surface having thereon a facecoating of an inoculant operable to nucleate grains during solidification and to cause an as-cast gamma titanium aluminide material to form a nearly equiaxed structure rather than a columnar structure at the surface of a casting;

casting into the mold a charge of a molten metal which, upon solidification, forms a gamma titanium aluminide material;

and

cooling the cast charge.

2. The method of claim 1, wherein the step of furnishing a mold includes the steps of

preparing a fugitive male model of the article;

depositing the facecoating inoculant on the exterior of the male model;

forming a female mold onto the exterior of the male model so that the inner surface of the mold contacts the male model;

and

removing the fugitive male model, leaving the facecoating inoculant affixed to the inner surface of the mold.

3. The method of claim 1, wherein the step of furnishing a mold includes the steps of

providing a permanent die-casting mold having the inner surface;

and

applying a coating of the facecoating inoculant to the inner surface of the permanent die-casting mold.

4. The method of claim 1, wherein the step of furnishing includes the step of

providing as the facecoating inoculant a compound of titanium.

5. The method of claim 1, wherein the step of furnishing includes the step of

providing as the facecoating inoculant a compound selected from the group consisting of titanium diboride and titanium carbide.

6. The method of claim 1, wherein the step of furnishing a mold includes the step of

furnishing a mold whose inner surface defines a structure selected from the group consisting of a turbine blade and a turbine vane.

7. The method of claim 1, wherein the step of casting includes the step of

providing a charge having a nominal composition, in atomic percent, selected from the group consisting of 46 percent aluminum, 2 percent chromium, 2 percent niobium, balance titanium totaling 100 percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium totaling 100 percent;

47 percent aluminum 4 percent niobium, 1 percent tungsten, balance titanium totaling 100 percent;

and 47 percent aluminum, 1 percent manganese, 2 percent niobium, small amounts of tungsten, molybdenum, or silicon, balance titanium totaling 100 percent.

8. A method of preparing a gamma titanium aluminide article, comprising the steps of:

furnishing a mold having an inner surface defining the shape of an article, at least a portion of the inner surface having thereon a facecoating of an inoculant operable to nucleate grains during solidification and to cause an as-cast gamma titanium aluminide material to form a nearly equiaxed structure rather than a columnar structure at the surface of a casting;

casting into the mold a charge of a molten metal which, upon solidification, forms a gamma titanium aluminide material;

cooling the cast charge;

and thereafter

hot isostatically pressing the cast and cooled charge.

9. The method of claim 8 wherein the step of furnishing a mold includes the steps of

preparing a fugitive male model of the article;

depositing the facecoating inoculant on the exterior of the male model;

forming a female mold onto the exterior of the male model so that the inner surface of the mold contacts the male model;

and

removing the fugitive male model, leaving the facecoating inoculant affixed to the inner surface of the mold.

10. The method of claim 8 wherein the step of furnishing a mold includes the steps of

providing a permanent die-casting mold having the inner surface;

and

applying a coating of the facecoating inoculant to the inner surface of the permanent die-casting mold.

11. The method of claim 8, wherein the step of furnishing includes the step of

providing as the facecoating inoculant a compound of titanium.

12. The method of claim 8, wherein the step of furnishing includes the step of

providing as the facecoating inoculant a compound selected from the group consisting of titanium diboride and titanium carbide.

13. The method of claim 8, wherein the step of furnishing a mold includes the step of

furnishing a mold whose inner surface defines a structure selected from the group consisting of a turbine blade and a turbine vane.

14. The method of claim 8, wherein the step of casting includes the step of

providing a charge having a nominal composition, in atomic percent, selected from the group consisting of 46 percent aluminum, 2 percent chromium, 2 percent niobium, balance titanium totaling 100 percent;

48 percent aluminum, 2 percent manganese, 2 percent niobium, balance titanium totaling 100 percent, 47 percent aluminum 4 percent niobium, 1 percent tungsten, balance titanium totaling 100 percent;

and 47 percent aluminum, 1 percent manganese, 2 percent niobium, small amounts of tungsten, molybdenum, or silicon, balance titanium totaling 100 percent.

15. A method of preparing a gamma titanium aluminide article, comprising the steps of:

furnishing a mold having an inner surface defining the shape of an article, at least a portion of the inner surface having thereon a facecoating of an inoculant operable to nucleate grains during solidification of a molten metal which, upon solidification, forms a gamma titanium aluminide material;

casting into the mold a charge of a molten metal which, upon solidification, forms a gamma titanium aluminide material having nearly equiaxed grains at the surface of the casting adjacent to the inner surface of the mold;

and

cooling the cast charge.

16. The method of claim 15, wherein the step of furnishing includes the step of providing as the facecoating inoculant a compound selected from the group consisting of titanium diboride and titanium carbide.


17. The method of claim 15, wherein the step of casting includes the step of providing a charge having a nominal composition, in atomic percent, selected from the group consisting of 46 percent aluminum, 2 percent chromium, 2 percent niobium, balance titanium totaling 100 percent;

48 percent aluminum, 2 manganese, 2 niobium, balance titanium totaling 100 percent;

47 percent aluminum 4 percent niobium, 1 percent tungsten, balance titanium totaling 100 percent;

and 47 percent aluminum, 1 percent manganese, 2 percent niobium, small amounts of tungsten, molybdenum, or silicon, balance titanium totaling 100 percent.

Titanium aluminide alloy with improved temperature capability US5545265

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor AUSTIN CURTISS M KELLY THOMAS J HUANG SHYH-CHIN • International Patent Classification C22C-014/00 • US Patent Classification PCLO=148421000 PCLX=420418000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5545265 A 1996-08-13 [US5545265] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1995US-08405318 1995-03-16 				
<ul style="list-style-type: none"> • Family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">US5545265</td> <td style="width: 10%; text-align: center;">A</td> <td style="width: 20%; text-align: center;">1996-08-13</td> <td style="width: 30%; text-align: right;">[US5545265]</td> </tr> </table> 		US5545265	A	1996-08-13	[US5545265]
US5545265	A	1996-08-13	[US5545265]		

- **Abstract:**
(US5545265)
A gamma titanium aluminide alloy is provided, based on the intermetallic compound TiAl, in which the resulting alloy is characterized by high creep strength and environmental resistance at elevated temperatures in excess of about 650 DEG C., and as high as about 850 DEG C. The alloy achieves these desirable properties through limited and interrelated additions of chromium, niobium and tantalum, whose combined amount is established by a minimum amount necessary to achieve a desired level of oxidation resistance.

Claims

(US5545265)

What is claimed is:

1.

A gamma titanium aluminide intermetallic alloy consisting essentially of, in atomic percent:

about 45 to about 49 percent aluminum;

about 1.2 to about 2.3 percent chromium;

about 0.5 to 0.9 percent niobium;

and

about 1 to about 2.3 percent tantalum;

the balance being essentially titanium and incidental impurities;

wherein (Cr+Nb+Ta) is at least about 3.5 percent but not more than about 4.9 percent.

2. An alloy as recited in claim 1 wherein the alloy contains, in atomic percent, about 46.5 to about 47.8 percent aluminum and about 1.7 to about 1.9 percent chromium.

3. An alloy as recited in claim 1 wherein the alloy contains, in atomic percent, about 1.7 to about 2 percent tantalum.

4. An alloy as recited in claim 1 wherein (Cr+Nb+Ta) is at least about 4.1 percent.

5. An alloy as recited in claim 1 wherein the alloy further contains about 1000 to about 3000 ppm oxygen.

6. An alloy as recited in claim 1 wherein the alloy further contains not more than about 500 ppm iron, not more than about 600 ppm nitrogen, not more than about 2200 ppm silicon, and not more than about 1000 ppm carbon.

7. An alloy as recited in claim 1 wherein the alloy further contains boron or titanium diboride.

8. An alloy as recited in claim 1 wherein the alloy further contains tungsten.

9. A gamma titanium aluminide intermetallic alloy consisting essentially, in atomic percent, of:

about 46.5 to about 47.8 percent aluminum;

about 1.7 to about 1.9 percent chromium;

about 0.7 to about 0.9 percent niobium;

about 1.7 to about 2 percent tantalum;

about 1000 to about 3000 ppm oxygen;

not more than about 500 ppm iron;

not more than about 600 ppm nitrogen;

not more than about 2200 ppm silicon;

and

not more than about 1000 ppm carbon;

the balance being essentially titanium and incidental impurities;

wherein (Cr+Nb+Ta) is at least about 3.5 percent but not more than about 4.9 percent.

10. A cast component formed from a gamma titanium aluminide intermetallic alloy consisting essentially of, in atomic percent:

about 45 to about 49 percent aluminum;

about 1.2 to about 2.3 percent chromium;

about 0.5 to 0.9 percent niobium;

and

about 1 to about 2.3 percent tantalum;

the balance being essentially titanium and incidental impurities;

wherein (Cr+Nb+Ta) is at least about 3.5 percent but not more than about 4.9 percent.

11. A cast component as recited in claim 10 wherein the alloy contains, in atomic percent, about 46.5 to about 47.8 percent aluminum and about 1.7 to about 1.9 percent chromium.

12. A cast component as recited in claim 10 wherein the alloy contains, in atomic percent, about 1.7 to about 2 percent tantalum.


13. A cast component as recited in claim 10 wherein (Cr+Nb+Ta) is at least about 4.1 percent.

14. A cast component as recited in claim 10 wherein the cast component has a maximum service temperature in excess of 650 (degree) C.

15. A cast component as recited in claim 10 wherein the cast component is employed in an intermediate stage in a low pressure turbine section of a high-bypass gas turbine engine.

Processing of gamma titanium-aluminide alloy using a heat treatment prior to deformation processing

US5609698

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor KELLY THOMAS J AUSTIN CURTISS M ALLEN ROBERT E • International Patent Classification C22F-001/18 • US Patent Classification PCLO=148671000 PCLX=148670000 • CPC Code C22F-001/18/3 	<ul style="list-style-type: none"> • Publication Information US5609698 A 1997-03-11 [US5609698] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1995US-08376519 1995-01-23
<ul style="list-style-type: none"> • Fampat family US5609698 A 1997-03-11 [US5609698] 	

- **Abstract:**

(US5609698)

An as-cast gamma titanium-aluminide alloy, typically having a composition of from about 45.0 to about 48.5 atomic percent aluminum, is pre-HIP heat treated at a temperature of from about 1900 DEG F. to about 2100 DEG F. for a time of from about 50 to about 5 hours. The gamma titanium-aluminide alloy is thereafter hot isostatically pressed at a temperature of about 2200 DEG F. Hot isostatic pressing is preferably followed by a further heat treatment at a temperature of about 1850 DEG - 2200 DEG F.

Claims

(US5609698)

What is claimed is:

1.

A method for processing a titanium-aluminide alloy, comprising the steps of:

furnishing an as-cast gamma titanium-aluminide alloy having a metastable microstructure, the alloy being in the shape of an article selected from the group consisting of a low-pressure turbine blade, a low-pressure turbine vane, a bearing support, a compressor casing, a high-pressure hanger, a low-pressure hanger, a frame, and a low pressure turbine brush seal support;

pretreating the gamma titanium-aluminide alloy to stabilize the metastable microstructure of the gamma titanium-aluminide alloy;

and

hot isostatic pressing the gamma titanium-aluminide alloy, the step of hot isostatic pressing to occur after the step of pretreating.

2. The method of claim 1, wherein the step of furnishing includes the step of

furnishing the gamma titanium-aluminide alloy in an as-cast form.

3. The method of claim 1, wherein the step of furnishing a gamma titanium-aluminide alloy includes the step of

furnishing an alloy selected from the group having compositions, in atomic percent, of Ti-48Al-2Cr-2Nb, Ti-48Al-2Mn-2Nb, Ti-49Al-1V, Ti-47Al-1Mn-2Nb-0.5W-0.5Mo-.2Si, and Ti-47Al-5Nb-1W.

4. The method of claim 1, wherein the step of pretreating includes the step of

heating the gamma titanium-aluminide alloy to a pretreatment temperature of from about 1900 (degree) F. to about 2100 (degree) F.

5. The method of claim 4, wherein the step of heating includes the step of

maintaining the gamma titanium-aluminide alloy at the heat treatment temperature for a time of from about 5 to about 50 hours.

6. The method of claim 1, including an additional step, after the step of hot isostatic pressing is complete, of

heat treating the gamma titanium-aluminide alloy.

7. The method of claim 6, wherein the step of heat treating includes the step of

heating the gamma titanium-aluminide alloy to a temperature of from about 1850 (degree) F. to about 2200 (degree) F. for a time of from about 20 hours to about 2 hours.

8. A method for processing a titanium alloy, comprising the steps of:

furnishing a gamma titanium-aluminide alloy in an as-cast form;

pre-HIP heat treating the gamma titanium-aluminide alloy at a pre-HIP heat treatment temperature of about the eutectoid temperature;

hot isostatic pressing the gamma titanium-aluminide alloy, the step of hot isostatic pressing to occur after the step of pre-HIP heat treating;

and, after the step of hot isostatic pressing is complete,

heat treating the gamma titanium-aluminide alloy by heating the gamma titanium-aluminide alloy to a temperature of from about 1850 (degree) F. to about 2200 (degree) F. for a time of from about 20 hours to about 2 hours.

9. The method of claim 8, wherein the step of furnishing includes the step of

furnishing a titanium-aluminide alloy having from about 45.0 to about 48.5 atomic percent aluminum, and

wherein the step of pre-HIP heat treating includes the step of

heating the gamma titanium-aluminide alloy to a pre-HIP heat treatment temperature of from about 1900 (degree) F. to about 2100 (degree) F.

10. The method of claim 9, wherein the step of heating includes the step of

maintaining the gamma titanium-aluminide alloy at the pre-HIP heat treatment temperature for a time of from about 5 to about 50 hours.

11. The method of claim 8, wherein the step of hot isostatic pressing includes the step of

hot isostatic pressing the gamma titanium-aluminide alloy at a temperature of from about 2150 (degree) F. to about 2300 (degree) F. at a pressure of from about 25,000 pounds per square inch to about 15,000 pounds per square inch and for a time of from about 3 hours to about 10 hours.

12. A method for processing a titanium alloy, comprising the steps of:

furnishing an as-cast gamma titanium-aluminide alloy having from about 45.0 to about 48.5 atomic percent aluminum;

pre-HIP heat treating the gamma titanium-aluminide alloy at a pre-HIP heat treatment temperature of from about 1900 (degree) F. to about 2100 (degree) F. for a time of from about 50 to about 5 hours;

hot isostatic pressing the gamma titanium-aluminide alloy at a temperature of about 2150 (degree) F., at a pressure of about

25,000 pounds per square inch, and for a time of from about 3 to about 5 hours, the step of hot isostatic pressing to occur after the step of pre-HIP heat treating is complete;

and


heat treating the gamma titanium-aluminide alloy at a temperature of from about 1850 (degree) F. to about 2200 (degree) F. for a time of from about 20 hours to about 2 hours, the step of heat treating to occur after the step of hot isostatic pressing is complete.

13. The method of claim 12, wherein the step of furnishing a gamma titanium-aluminide alloy includes the step of

furnishing an alloy selected from the group having compositions, in atomic percent, of Ti-48Al-2Cr-2Nb, Ti-48Al-2Mn-2Nb, Ti-49Al-1V, Ti-47Al-1Mn-2Nb-0.5W-0.5Mo-.2Si, and Ti-47Al-5Nb-1W.

Heat treatment of gamma titanium aluminide alloys

US6231699

<ul style="list-style-type: none">• Patent Assignee GENERAL ELECTRIC HOWMET • Inventor KELLY THOMAS J WEIMER MICHAEL J AUSTIN CURTISS M LONDON BLAIR LARSON JR DONALD E WHEELER DEAN A • International Patent Classification C22C-014/00 C22F-001/18 • US Patent Classification PCLO=148670000 PCLX=148421000 • CPC Code C22C-014/00; C22F-001/18/3	<ul style="list-style-type: none">• Publication Information US6231699 B1 2001-05-15 [US6231699] <div style="text-align: right; margin-top: -20px;"></div> <ul style="list-style-type: none">• Priority Details 1994US-08262168 1994-06-20
<ul style="list-style-type: none">• Fampat family US6231699 B1 2001-05-15 [US6231699]	

• **Abstract:**
(US6231699)
A gamma titanium aluminide alloy article, is prepared using a piece of a gamma titanium aluminide alloy having a composition capable of forming alpha, alpha-2, and gamma phases. The alpha transus temperature of the gamma titanium aluminide alloy piece is determined. The gamma titanium aluminide alloy piece is consolidated by hot isostatic pressing at a temperature of from about 50 F. to about 250 F. below the alpha transus temperature and at a pressure of from about 10,000 to about 30,000 pounds per square inch, for a duration of from about 1 to about 20 hours. The piece is heat treated at a temperature of from about 5 F. to about 300 F. below the alpha transus temperature for a time sufficient to refine the microstructure and generate a microstructure comprising from about 10 to about 90 volume percent gamma phase. The step of heat treating is conducted at a temperature of from about 45 F. to about 200 F. above the temperature of the step of hot isostatic pressing.

Claims

(US6231699)

What is claimed is:

1.

A method of producing a gamma titanium aluminide alloy article, comprising the steps of:

providing a piece of a gamma titanium aluminide alloy having a composition capable of forming alpha, alpha-2, and gamma phases;

determining the alpha transus temperature of the gamma titanium aluminide alloy piece;

consolidating the gamma titanium aluminide alloy piece at elevated temperature to reduce porosity therein;

wherein the step of consolidating the titanium aluminide piece includes the step of hot isostatic pressing the gamma titanium aluminide alloy piece, and

heat treating the piece at a temperature of from about 5 F. to about 300 F. below the alpha transus temperature for a time sufficient to generate a refined microstructure comprising from about 10 to about 90 volume percent gamma phase.

2. The method of claim 1, wherein the step of hot isostatic pressing is performed at a temperature of from about 50 F. to about 250 F. below the alpha transus temperature and at a pressure of from about 20,000 to about 30,000 pounds per square inch, for a duration of from about 1 to about 20 hours.

3. A method of producing a gamma titanium aluminide alloy article, comprising the steps of:

providing a piece of a gamma titanium aluminide alloy having a composition capable of forming alpha, alpha-2, and gamma phases;

determining the alpha transus temperature of the gamma titanium aluminide alloy piece;

hot isostatic pressing the gamma titanium aluminide alloy piece at a temperature of from about 50 F. to about 250 F. below the alpha transus temperature and at a pressure of from about 20,000 to about 30,000 pounds per square inch, for a duration of from about 1 to about 20 hours;

and

heat treating the piece at a temperature of from about 5 F. to about 300 F. below the alpha transus temperature for a time sufficient to refine the microstructure and generate a microstructure comprising from about 10 to about 90 volume percent gamma phase, the step of heat treating being conducted at a temperature of from about 45 F. to about 200 F. above the temperature of the step of hot isostatic pressing.

4. The method of claim 3, wherein the gamma titanium aluminide piece has a composition, in atomic percent, comprising from about 46 to about 50 percent aluminum.

5. The method of claim 3, wherein the gamma titanium aluminide piece has a composition, in atomic percent, consisting essentially of from about 46 to about 50 percent aluminum, from about 1 to about 3 percent chromium, from about 1 to about 5 percent niobium, balance titanium and incidental impurities.

6. The method of claim 3, wherein the gamma titanium aluminide piece has a composition, in atomic percent, consisting essentially of from about 43 to about 48 percent aluminum, from about 1 to about 3 percent chromium, from about 1 to about 5 percent niobium, from about 0.5 to about 2.0 percent boron, balance titanium and incidental impurities.

7. A method of producing a gamma titanium aluminide alloy article, comprising the steps of:

providing a piece of a gamma titanium aluminide alloy having a composition capable of forming alpha, alpha-2, and gamma phases;

determining the alpha transus temperature of the gamma titanium aluminide alloy piece;

hot isostatic pressing the gamma titanium aluminide alloy piece at a temperature of from about 125 F. to about 225 F. below the alpha transus temperature and at a pressure of from about 20,000 to about 25,000 pounds per square inch, for a duration of from about 2 to about 8 hours;

and

heat treating the piece at a temperature of from about 50 F. to about 100 F. below the alpha transus temperature for a time sufficient to refine the microstructure and generate a microstructure comprising from about 20 to about 80 volume percent gamma phase, the step of heat treating being conducted at a temperature of from about 50 F. to about 100 F. above the temperature of the step of hot isostatic pressing.


8. The method of claim 7, wherein the gamma titanium aluminide piece has a composition, in atomic percent, comprising from about 46 to about 50 percent aluminum.

9. The method of claim 7, wherein the gamma titanium aluminide piece has a composition, in atomic percent, consisting essentially of from about 46 to about 50 percent aluminum, from about 1 to about 3 percent chromium, from about 1 to about 5 percent niobium, balance titanium and incidental impurities.

10. The method of claim 7, wherein the gamma titanium aluminide piece has a composition, in atomic percent, consisting essentially of from about 43 to about 48 percent aluminum, from about 1 to about 3 percent chromium, from about 1 to about 5 percent niobium, from about 0.5 to about 2.0 percent boron, balance titanium and incidental impurities.

11. The method of claim 7, wherein the step of heat treating is performed immediately after the step of hot isostatic pressing, without allowing the piece to cool to an intervening lower temperature.

Tri-titanium aluminide alloys having improved combination of strength and ductility and processing method therefor
US5281285

<ul style="list-style-type: none"> • <u>Patent Assignee</u> GENERAL ELECTRIC • <u>Inventor</u> MARQUARDT BRIAN J • <u>International Patent Classification</u> C22C-014/00 • <u>US Patent Classification</u> PCLO=148670000 PCLX=148421000 PCLX=148671000 PCLX=420418000 • <u>CPC Code</u> C22C-014/00 	<ul style="list-style-type: none"> • <u>Publication Information</u> US5281285 A 1994-01-25 [US5281285]  • <u>Priority Details</u> 1992US-07905709 1992-06-29
<ul style="list-style-type: none"> • <u>Fampat family</u> US5281285 A 1994-01-25 [US5281285] 	

- **Abstract:**
(US5281285)
Tri-titanium aluminide alloys are preferably deformed and heat treated below the beta transus temperature of the alloys to produce an improved combination of mechanical properties, specifically elevated temperature yield strength and creep resistance, and room temperature ductility and toughness. A preferred composition consists essentially of, in atomic percent, 24.5% aluminum, 12.5% niobium, 1.5% molybdenum, balance titanium.

Claims

(US5281285)

I claim:

1. A tri-titanium aluminide alloy having improved room temperature ductility consisting essentially of, in atomic percent, about 22.5 percent to less than 25 percent aluminum, about 1 percent to about 2 percent molybdenum, about 10 percent to about 15 percent niobium, and the balance essentially titanium, wherein the alloy has a mixed microstructure comprising uniformly distributed grains of a primary alpha-2 phase and alpha-2 Widmanstatten platelets.

2. The tri-titanium aluminide alloy of claim 1, wherein the grains of the primary alpha-2 phase are no larger than about 50 microns in size.

3. The tri-titanium aluminide alloy of claim 1, wherein the volume percent of the primary alpha-2 phase is from about 2 percent to about 20 percent.

4. The tri-titanium aluminide alloy of claim 1, wherein the alloy has the mixed microstructure developed through a method of processing comprising the steps of:

heating the alloy to a first temperature in the range of from about 40 (degree) C. to about 300 (degree) C. below a beta transus of the alloy;

while holding the alloy at about the first temperature, working the alloy sufficiently so that its microstructure is refined and the primary alpha-2 phase is uniformly distributed throughout the microstructure;

heat treating the worked alloy at a second temperature above the first temperature and below the beta transus temperature and for a period of time sufficient to retain about 2 percent to about 20 percent of the primary alpha-2 phase;

and

cooling the worked alloy from the second temperature at a rate sufficient to produce the mixed microstructure.

5. The tri-titanium aluminide alloy of claim 4, wherein the first temperature is from about 40 (degree) C. to about 220 (degree) C. below the beta transus.

6. The tri-titanium aluminide alloy of claim 4, wherein the second temperature is greater than the first temperature and at least 30 (degree) C. below the beta transus.

7. The tri-titanium aluminide alloy of claim 4, wherein the step of working is accomplished by using an operation selected from the group of forging, cogging, rolling, extruding and swaging.

8. A tri-titanium aluminide alloy having improved room temperature ductility consisting essentially of, in atomic percent, about 22.5 percent to less than 25 percent aluminum, about 1 percent to about 2 percent molybdenum, about 10 percent to about 15 percent niobium, and the balance essentially titanium, wherein the alloy having a microstructure comprising alpha-2 Widmanstatten platelets which is developed through a method of processing comprising the steps of:

heating the alloy to a first temperature from about 40 (degree) C. to about 300 (degree) C. below a beta transus of the alloy;

then

working the alloy sufficiently so that its microstructure is refined and a primary alpha-2 phase is uniformly distributed throughout the microstructure;

then

heating the alloy to a second temperature from about 25 (degree) C. to about 40 (degree) C. above the beta transus of the alloy to produce a substantially fully beta structure;

further working the alloy to deform the beta grains;

cooling the alloy quickly enough so that less than about 20 percent by volume of the beta phase recrystallizes and so that a fine Widmanstatten structure substantially without primary alpha-2 is produced;

and then

optionally aging the alloy at a third temperature in the range of from about 650 (degree) to about 700 (degree) C.

9. The tri-titanium aluminide alloy of claim 8, wherein the first temperature is from about 40 (degree) C. to about 165 (degree) C. below the beta transus.

10. A tri-titanium aluminide alloy having improved room temperature ductility consisting essentially of, in atomic percent, about 22.5 percent to less than 25 percent aluminum, about 1 percent to about 2 percent molybdenum, about 10 percent to about 15 percent niobium, and the balance essentially titanium, wherein the alloy having a mixed microstructure comprising alpha-2 Widmanstatten platelets which is developed through a method of processing comprising the steps of

heating the alloy to a first temperature in the range of from about 40 (degree) C. to about 300 (degree) C. below a beta transus of the alloy;

then

working the alloy sufficiently so that its microstructure is refined and a primary alpha-2 phase is uniformly distributed through the microstructure;

then

heating the alloy to a second temperature in the range of from about 25 (degree) C. to about 40 (degree) C. above the beta transus of the alloy to produce a substantially fully beta structure;

then

cooling the alloy quickly enough so that a fine Widmanstatten structure substantially without primary alpha-2 is produced;

followed by

heating the alloy to a third temperature, in the range of from 40 (degree) C. to about 220 (degree) C. below the beta transus of the alloy;

then

rolling the alloy into sheet configuration;


and then

heating the alloy to a fourth temperature, below the beta transus of the alloy and above the third temperature.

11. The tri-titanium aluminide alloy of claim 10, wherein the first temperature is from about 40 (degree) to about 165 (degree) C. below the beta transus.

Wrought gamma titanium aluminide alloys modified by chromium, boron, and niobium.

US5205875

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-014/00 C22F-001/00 C22F-001/18 • US Patent Classification PCLO=148421000 PCLX=148670000 PCLX=420418000 PCLX=420421000 • CPC Code C22C-014/00; C22F-001/18/3 	<ul style="list-style-type: none"> • Publication Information US5205875 A 1993-04-27 [US5205875] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1991US-07801557 1991-12-02 												
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">US5205875</td> <td style="width: 10%; text-align: center;">A</td> <td style="width: 20%;">1993-04-27</td> <td style="width: 30%;">[US5205875]</td> </tr> <tr> <td>EP0545613</td> <td style="text-align: center;">A1</td> <td>1993-06-09</td> <td>[EP-545613]</td> </tr> <tr> <td>JPH05255781</td> <td style="text-align: center;">A</td> <td>1993-10-05</td> <td>[JP05255781]</td> </tr> </table> 		US5205875	A	1993-04-27	[US5205875]	EP0545613	A1	1993-06-09	[EP-545613]	JPH05255781	A	1993-10-05	[JP05255781]
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EP0545613	A1	1993-06-09	[EP-545613]										
JPH05255781	A	1993-10-05	[JP05255781]										

- **Abstract:**

(EP-545613)


A TiAl composition is prepared to have high strength and to have improved ductility by altering the atomic ratio of the titanium and aluminum to have what has been found to be an effective aluminum concentration and by addition of chromium, boron, and niobium according to the approximate formula Ti-Al₄₆₋₄₈ Cr₂ Nb₂ B_{0.1-0.2}. The composition is preferably prepared by casting, homogenization at a high temperature, and forging the homogenized casting. (see diagramm 1 page 0)

Claims

(EP-545613)

1. A cast and wrought body of alloy, said alloy consisting essentially of a gamma titanium aluminide modified by chromium, niobium, and boron according to the expression: Ti-Al4 6 - 5 0 Cr1 - 3 Nb1 - 5 B0.05-0.3 ., said body having been homogenized for one to three hours at a temperature close to or above the alpha transus temperature, and said body having been wrought to cause a deformation thereof of at least 10% and annealed.
2. A cast and wrought body of alloy, said alloy consisting essentially of a gamma titanium aluminide modified by chromium, niobium, and boron according to the expression: Ti-Al4 6 - 5 0 Cr1 - 3 Nb2 B0.1-0.2 ., said body having been homogenized for one to three hours at a temperature close to or above the alpha transus temperature, and said body having been wrought to cause a deformation thereof of at least 10% and annealed.
3. A cast and wrought body of alloy, said alloy consisting essentially of a gamma titanium aluminide modified by chromium, niobium, and boron according to the expression: Ti-Al4 6 - 5 0 Cr2 Nb1 - 5 B0.05-0.3 ., said body having been homogenized for one to three hours at a temperature close to or above the alpha transus temperature, and said body having been wrought to cause a deformation thereof of at least 10% and annealed.
4. A cast and wrought body of alloy, said alloy consisting essentially of a gamma titanium aluminide modified by chromium, niobium, and boron according to the expression: Ti-Al4 6 - 4 8 Cr2 Nb2 B0.2 ., said body having been homogenized for one to three hours at a temperature close to or above the alpha transus temperature, and said body having been wrought to cause a deformation thereof of at least 10% and annealed.
5. A cast and wrought body of alloy, said alloy consisting essentially of a gamma titanium aluminide modified by chromium, niobium, and boron according to the expression: Ti-Al4 6 - 4 8 Cr2 Nb2 B0.2 ., said body having been homogenized for one to three hours at a temperature close to or above the alpha transus temperature, and said body having been wrought to cause a deformation thereof of at least 10% and annealed.

Method for melting titanium aluminide alloys US5102450

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN NMN • International Patent Classification C22B-009/22 C22C-001/02 C22C-014/00 F27B-014/10 • US Patent Classification PCLO=075010650 • CPC Code C22C-001/02; C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5102450 A 1992-04-07 [US5102450] <div style="text-align: right; margin-top: 5px;">  </div> <ul style="list-style-type: none"> • Priority Details 1991US-07739004 1991-08-01 																																
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- **Abstract:**

(EP-526159)


Gamma titanium aluminide alloys can be melted by a method comprising, melting a charge comprised of the titanium aluminide alloy and an effective amount of a metal from the group consisting of niobium, tantalum, tungsten, and molybdenum to reduce oxygen pickup in the melt, the melting being performed in a calcia crucible.

Claims

(EP-526159)

1. A method of melting a gamma titanium aluminide alloy comprising, melting a charge comprised of the titanium aluminide alloy and an effective amount of a metal from the group consisting of niobium, tantalum, tungsten, and molybdenum to reduce oxygen pickup in the melt, the melting being performed in a calcia crucible.
2. The method of claim 1 wherein the metal is niobium.
3. The method of Claim 1 or Claim 2 wherein an effective amount is about 2 to 12 atom percent.
4. The method of any preceding claim wherein an effective amount is about 4 to 8 atom percent.
5. The method of any preceding claim wherein the charge is formed so that titanium in the charge has minimized contact with the crucible.

Titanium aluminide containing chromium, tantalum, and boron IT91MI3381

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-001/00 C22C-001/02 C22C-014/00 C22F-001/00 C22F-001/18 • US Patent Classification PCLO=148421000 PCLX=148546000 PCLX=420418000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information ITMI913381 D0 1991-12-17 [IT91MI3381] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1990US-07631988 1990-12-21 																																																												
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- **Abstract:**

(US5131959)

A method for providing improved ductility in a gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing chromium and tantalum and thermomechanically working the casting. Boron additions are made in concentrations between 0.5 and 2 atomic percent. Fine grain equiaxed microstructure is found from solidified melt. Property improvements are achieved by the thermomechanical processing.

Claims

(US5131959)

What is claimed is:

1.

A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and

the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

2. A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and

the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

3. A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and

the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

4. A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and

the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

5. A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and


the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

6. A structural metal element, said element having the following approximate composition:

said element having been cast and then mechanically deformed while in a heated condition and

the metal of said element having a yield strength of at least 80 ksi, a rupture strength of at least 90 ksi, and a plastic elongation of at least 1.5%.

Niobium containing titanium aluminide rendered castable by boron inoculations. US5082624

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH CHIN • International Patent Classification B22D-027/20 C22C-001/02 C22C-014/00 • US Patent Classification PCLO=420418000 PCLX=148421000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5082624 A 1992-01-21 [US5082624] <div style="text-align: right; margin-top: 5px;">  </div> <ul style="list-style-type: none"> • Priority Details 1990US-07589827 1990-09-26 																																								
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- **Abstract:**

(EP-477560)

A composition for providing improved castability in a gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing higher concentrations of niobium. Boron additions are made in concentrations between 0.5 and 2 atomic percent. Fine grain equiaxed microstructure is found from solidified melt. Property improvements are also achieved. (see diagramm 1 page 0)

Claims

(EP-477560)

1. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti34-50.5Al4 3 - 4 8 Nb6 - 1 6 B0.5-2.0 .

2. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti34.5-50Al4 3 - 4 8 Nb6 - 1 6 B1.0-1.5 .

3. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti38-50.5Al4 3 - 4 8 Nb6 - 1 2 B0.5-2.0 .

4. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti40-48.5Al44.5-46.5Nb6 - 1 2 B1.0-1.5 .

5. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti41.5-47Al44.5-46.5Nb8 - 1 0 B0.5-2.0 .

6. A castable composition comprising titanium, aluminum, niobium, and boron in the following approximate composition:

Ti42-46.5Al44.5-46.5Nb8 - 1 0 B1.0-1.5 .

7. A structural element, said element being a casting of a composition having the following approximate composition:

Ti34-50.5Al4 3 - 4 8 Nb6 - 1 6 B0.5-2.0 .

8. A structural element, said element being a casting of a composition having the following approximate composition:

Ti34.5-50Al4 3 - 4 8 Nb6 - 1 6 B1.0-1.5 .

9. A structural element, said element being a casting of a composition having the following approximate composition:

Ti38-50.5Al4 3 - 4 8 Nb6 - 1 2 B0.5-2.0 .

10. A structural element, said element being a casting of a composition having the following approximate composition:

Ti40-48.5Al44.5-46.5Nb6 - 1 2 B1.0-1.5 .


11. A structural element, said element being a casting of a composition having the following approximate composition:

Ti41.5-47Al44.5-46.5Nb8 - 1 0 B0.5-2.0 .

12. A structural element, said element being a casting of a composition having the following approximate composition:

Ti42-46.5Al44.5-46.5Nb8 - 1 0 B1.0-1.5 .

Process of forming niobium and boron containing titanium aluminide. US5082506

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification B22D-027/20 C22C-001/02 C22C-014/00 • US Patent Classification PCLO=148557000 PCLX=148421000 PCLX=148670000 PCLX=148671000 PCLX=148707000 PCLX=420418000 PCLX=420419000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5082506 A 1992-01-21 [US5082506] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1990US-07589823 1990-09-26 																																								
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- **Abstract:**

(EP-477559)

A method for providing improved ductility in a castable gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing higher concentrations of niobium and thermomechanically working the casting. Boron additions are made in concentrations between 0.5 and 2 atomic percent. Fine grain equiaxed microstructure is found from solidified melt. Property improvements are achieved by the thermomechanical processing. (see diagramm 1 page 0)

Claims

(EP-477559)

1. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti34-50.5 Al4 3 - 4 8 Nb6 - 1 6 B0.5-2.0

and thermomechanically working the cast composition.

2. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti34.5-50 Al4 3 - 4 8 Nb6 - 1 6 B1.0-1.5

and thermomechanically working the cast composition.

3. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti38-50.5 Al4 3 - 4 8 Nb6 - 1 2 B0.5-2.0

and thermomechanically working the cast composition.

4. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti40-48.5 Al44.5-46.5 Nb6 - 1 2 B1.0-1.5

and thermomechanically working the cast composition.

5. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti41.5-47 Al44.5-46.5 Nb8 - 1 0 B0.5-2.0

and thermomechanically working the cast composition.


6. A method of forming a composition of titanium, aluminum, niobium, and boron of higher ductility comprising casting the following approximate composition:

Ti42-46.5 Al44.5-46.5 Nb8 - 1 0 B1.0-1.5

and thermomechanically working the cast composition.

Tantalum and chromium containing titanium aluminide rendered castable by boron inoculation

IT91MI1563

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor SHYH-CHIN HUANG • International Patent Classification C22C-014/00 • US Patent Classification PCLO=420418000 PCLX=148421000 PCLX=420417000 PCLX=420590000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information ITMI911563 D0 1991-06-06 [IT91MI1563] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1990US-07546962 1990-07-02 																																																								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 30%;">ITMI911563</td> <td style="width: 10%;">D0</td> <td style="width: 20%;">1991-06-06</td> <td style="width: 40%;">[IT91MI1563]</td> </tr> <tr> <td>GB9112853</td> <td>D0</td> <td>1991-07-31</td> <td>[GB9112853]</td> </tr> <tr> <td>FR2663956</td> <td>A1</td> <td>1992-01-03</td> <td>[FR2663956]</td> </tr> <tr> <td>ITMI911563</td> <td>A1</td> <td>1992-01-03</td> <td>[IT91MI1563]</td> </tr> <tr> <td>CA2042272</td> <td>A1</td> <td>1992-01-03</td> <td>[CA2042272]</td> </tr> <tr> <td>GB2245593</td> <td>A</td> <td>1992-01-08</td> <td>[GB2245593]</td> </tr> <tr> <td>DE4121215</td> <td>A1</td> <td>1992-01-16</td> <td>[DE4121215]</td> </tr> <tr> <td>US5098653</td> <td>A</td> <td>1992-03-24</td> <td>[US5098653]</td> </tr> <tr> <td>JPH0570871</td> <td>A</td> <td>1993-03-23</td> <td>[JP05070871]</td> </tr> <tr> <td>GB2245593</td> <td>B</td> <td>1994-03-30</td> <td>[GB2245593]</td> </tr> <tr> <td>DE4121215</td> <td>C2</td> <td>1994-10-27</td> <td>[DE4121215]</td> </tr> <tr> <td>IT1248003</td> <td>B</td> <td>1995-01-05</td> <td>[IT1248003]</td> </tr> <tr> <td>FR2663956</td> <td>B1</td> <td>1995-03-03</td> <td>[FR2663956]</td> </tr> <tr> <td>JPH0830236</td> <td>B2</td> <td>1996-03-27</td> <td>[JP96030236]</td> </tr> </tbody> </table>		ITMI911563	D0	1991-06-06	[IT91MI1563]	GB9112853	D0	1991-07-31	[GB9112853]	FR2663956	A1	1992-01-03	[FR2663956]	ITMI911563	A1	1992-01-03	[IT91MI1563]	CA2042272	A1	1992-01-03	[CA2042272]	GB2245593	A	1992-01-08	[GB2245593]	DE4121215	A1	1992-01-16	[DE4121215]	US5098653	A	1992-03-24	[US5098653]	JPH0570871	A	1993-03-23	[JP05070871]	GB2245593	B	1994-03-30	[GB2245593]	DE4121215	C2	1994-10-27	[DE4121215]	IT1248003	B	1995-01-05	[IT1248003]	FR2663956	B1	1995-03-03	[FR2663956]	JPH0830236	B2	1996-03-27	[JP96030236]
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- **Abstract:**

(US5098653)

A method for providing improved castability in a gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing chromium and tantalum. Boron additions are made in concentrations between 0.5 to 2 atomic percent. Fine grain equiaxed microstructure is formed from solidified melt. Property improvements are also achieved.

Claims

(US5098653)

What is claimed is:

1.

A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate composition:

2. A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate compositions:

3.

A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate composition:

4.

A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate composition:

5.

A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate composition:

6.

A castable composition having a fine, equiaxed microstructure in the as-cast state comprising titanium, aluminum, chromium, tantalum, and boron in the following approximate composition:

7.

A structural element, said element being a casting having a fine, equiaxed microstructure in the as-cast state and formed of a composition having the following approximate composition:

8.

A structural element, said element being a casting having a fine, equiaxed microstructure in the as-cast state and formed of a composition having the following approximate compositions:

9.

A structural element, said element being a casting having a fine, equiaxed microstructure in the as-cast state and formed of a composition having the following approximate compositions:

10.

A structural element, said element being a casting having a fine, equiaxed microstructure in the as-cast state and formed of a composition having the following approximate composition:

11.


A structural element, said element being a casting having a fine, equiaxed microstructure in the following approximate composition:

12.

A structural element, said element being a casting having a fine, equiaxed microstructure in the as-cast state and formed of a composition having the following approximate compositions:

Niobium and chromium containing titanium aluminide rendered castable by boron inoculations

IT91MI1656

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-014/00 • US Patent Classification PCLO=420418000 PCLX=148421000 PCLX=420417000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information ITMI911656 D0 1991-06-17 [IT91MI1656] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1990US-07546973 1990-07-02 																																																												
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- **Abstract:**

(US5080860)

A method for providing improved castability in a gamma titanium aluminide is taught. The method involves adding inclusions of boron to the titanium aluminide containing chromium and niobium. Boron additions are made in concentrations between 0.5 and 2 atomic percent. Fine grain equiaxed microstructure is found from solidified melt. Property improvements are also achieved.

Claims

(US5080860)

What is claimed is:

1.

A castable composition having equiaxed, fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

2. A castable composition having equiaxed, fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

3.

A castable composition having equiaxed, fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

4.

A castable composition having equiaxed, fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

5.

A castable composition having equiaxed, the fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

6.

A castable composition having equiaxed, fine grain microstructure in the as cast form comprising titanium, aluminum, chromium, niobium, and boron in the following approximate composition:

7.

A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

8.

A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

9.

A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

10.

A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

11.


A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

12.

A structural element, said element being a casting having equiaxed, fine grain microstructure in the as cast form of a composition having the following approximate composition:

Silicon carbide filament reinforced titanium aluminide matrix with reduced cracking tendency

GB9024187

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor SIEMERS PAUL A RITTER ANN M • International Patent Classification C22C-014/00 C22C-047/00 C22C-047/02 C22C-047/04 C22C-047/18 C22F-001/18 C23C-004/06 • US Patent Classification PCLO=428614000 PCLX=427455000 • CPC Code C22C-047/18; Y10T-428/12486 	<ul style="list-style-type: none"> • Publication Information GB9024187 D0 1990-12-19 [GB9024187] <li style="text-align: right;"> • Priority Details 1989US-07455041 1989-12-22 																																												
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- **Abstract:**

(US5017438)

A method for forming a composite having a matrix which is stronger and which is resistant to cracking is disclosed. The composite is reinforced by silicon carbide fibers. The silicon carbide fibers are first RF plasma-spray coated with a niobium metal and the matrix metal of titanium base alpha-2 crystal structure is next RF plasma-spray deposited over the niobium coated SiC fibers to form a layer of Ti base metal reinforced by SiC fibers. A plurality of layered structures are consolidated by heat and pressure into a composite structure.

Claims

(US5017438)

What is claimed is:

1.

A reinforced structure which comprises,
a set of reinforcing silicon carbide filaments,
a partial and irregular coating of plasma-spray deposited beta-phase stabilizer metal on the silicon carbide filaments, and
a matrix of a titanium base alloy having an alpha-2 crystal form extending between said coated filaments as a matrix of a composite structure.

2. The structure of claim 1, in which the beta-phase stabilizer is an alloy of niobium which is resistant to oxidation.

3. The structure of claim 1, in which the beta-phase stabilizer is elemental niobium.

4. The structure of claim 1, in which the irregularity of the coating is with respect to uneven thickness and uneven distribution about the filament surface.

5. The structure of claim 1, in which the titanium base metal is Ti-1421.


6. The structure of claim 1, in which the structure is densified by heat and pressure.

7. The structure of claim 1, in which the structure is HIPed to higher density.

8. The structure of claim 1, in which the structure is vacuum hot pressed to densify the matrix thereof.

9. The method of forming a strong composite structure resistant to matrix cracking which comprises,
providing a set of reinforcing silicon carbide filaments,
plasma-spray coating said filaments with an irregular partial and surface layer of a beta-phase stabilizer metal, and
plasma-spray depositing a matrix of a titanium base metal on said set of beta-phase stabilizer coated silicon carbide filaments to form a crack resistant composite structure.

Tri-titanium aluminide base alloys of improved strength and ductility US4788035

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor GIGLIOTTI, MICHAEL FRANCIS XAVIER, JR. MARQUARDT, BRIAN JAY • International Patent Classification C22C-014/00 • US Patent Classification PCLO=420420000 PCLX=148421000 PCLX=420418000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US4788035 A 1988-11-29 [US4788035]  <ul style="list-style-type: none"> • Priority Details 1987US-07056515 1987-06-01 																								
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- **Abstract:**

(EP-293689)





A titanium aluminide base composition is provided which has increased tensile strength, ductility and rupture life due to the addition of tantalum coupled with optional additions of vanadium and columbium.

Claims

(EP-293689)

1. A composition having a titanium aluminide base and having good tensile strengths and ductilities and high creep resistance which comprises a composition containing a matrix phase based on Ti₃Al and containing additions of vanadium, columbium and tantalum wherein the additions are in the following proportions:
 - (a) no less than about 2 atomic % tantalum;
 - (b) no more than about 5 atomic % of either vanadium or columbium;
 - (c) the sum of atomic % tantalum, columbium and vanadium exceeding 5%.
2. The composition of claim 1 in which tensile elongation is in excess of 5% at 260 DEG.C and wherein the tantalum is present to the extent of 2 to 7.5 atomic % and the columbium is present to the extent of 2.5 to 5 atomic %.
3. A titanium aluminide composition containing 20-26 atomic % aluminum, 6 to 7.5 atomic % tantalum, 2.5 to 4 atomic percent columbium and 0 to 1.5 atomic % vanadium.
4. The composition of claim 1 in which substituent additions of hafnium or zirconium for titanium are made.
5. The composition of claim 1 in which substituent additions of molybdenum or tungsten are made for tantalum, vanadium or columbium.
6. The composition of claim 1 in which substituent additions of tin, indium and gallium for aluminum are made.
7. The composition of claim 1 in which strain aging additions of silicon and/or germanium are made.

Silicon-carbide reinforced composites of titanium aluminide US4786566

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC PETERS CONSUMER BRANDS PETERS CONSUMER BRANDS INTERNATIONAL POLAROID POLAROID EYEWEAR ZINK • Inventor SIEMERS, PAUL ALFRED • International Patent Classification B22D-023/00 C22C-047/18 C22C-049/11 C23C-004/08 H05H-001/46 • US Patent Classification PCLO=428568000 PCLX=228262710 PCLX=427456000 PCLX=428567000 PCLX=428937000 • CPC Code B22F-2998/10; C22C-047/06/8; C22C-047/18; C22C-049/11; H05H-001/46; Y10S-428/937; Y10T-428/12167 Y10T-428/1216; 	<ul style="list-style-type: none"> • Publication Information US4786566 A 1988-11-22 [US4786566]     • Priority Details 1987US-07010882 1987-02-04 1988EP-0115079 1988-09-15 1988IL-0087841 1988-09-23 																												
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">US4786566</td> <td style="width: 10%;">A</td> <td style="width: 20%;">1988-11-22</td> <td style="width: 40%;">[US4786566]</td> </tr> <tr> <td>EP0358799</td> <td>A1</td> <td>1990-03-21</td> <td>[EP-358799]</td> </tr> <tr> <td>IL87841</td> <td>A</td> <td>1991-07-18</td> <td>[IL--87841]</td> </tr> <tr> <td>EP0358799</td> <td>B1</td> <td>1993-04-14</td> <td>[EP-358799]</td> </tr> <tr> <td>DE3880312</td> <td>D1</td> <td>1993-05-19</td> <td>[DE3880312]</td> </tr> <tr> <td>GR3007656</td> <td>T3</td> <td>1993-08-31</td> <td>[GR3007656]</td> </tr> <tr> <td>DE3880312</td> <td>T2</td> <td>1993-11-25</td> <td>[DE3880312]</td> </tr> </table> 		US4786566	A	1988-11-22	[US4786566]	EP0358799	A1	1990-03-21	[EP-358799]	IL87841	A	1991-07-18	[IL--87841]	EP0358799	B1	1993-04-14	[EP-358799]	DE3880312	D1	1993-05-19	[DE3880312]	GR3007656	T3	1993-08-31	[GR3007656]	DE3880312	T2	1993-11-25	[DE3880312]
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- **Abstract:**

(EP-358799)

A method of forming a composite of fibers having high strength at high temperatures in a high temperature metal matrix is taught. The high strength fibers may be silicon carbide fibers. The fibers are aligned and disposed on a substrate surface. A metal to serve as a matrix is provided in powder form with relatively larger particles of the order of more than 100 m. The powder is plasma spray deposited on the fiber coated substrate surface to cause the metal to at least partially envelop the fibers. The composite is then separated from the substrate.

Claims

(EP-358799)

1. The method of forming filaments reinforced metal matrix materials which comprises disposing an array of aligned high strength high temperature filaments on a receiving surface providing, in powdered form, a titanium base metal to serve as a matrix to said fibers, radio frequency plasma spray depositing said metal onto said array of filaments to at least partially impregnate said array and embed said filaments in the metal foil deposit formed by said plasma spray.
2. The method of claim 1 in which the high strength, high temperature filaments are of silicon carbide.
3. The method of claim 1 in which the radio frequency used is between 2 and 5 megahertz.
4. The method of claim 1 in which the radio frequency used is between 2 and 3 megahertz.
5. The method of claim 1 in which the titanium base alloy is Ti-6Al-4V.
6. The method of claim 1 in which the titanium base alloy is Ti-6242.
7. The method of claim 1 in which the titanium base alloy is Ti-14Al-21Cb.
8. The method of claim 1 in which the titanium base alloy is TiAl.
9. The method of claim 1 in which the titanium base alloy is TiAl₃.
10. A composite structure comprising a plurality of aligned high strength, high temperature filaments, said filaments being embedded in a host metal of rapidly solidified titanium base alloy metal.
11. The composite structure of claim 10 in which the oxygen content of the titanium base alloy is below 2000 ppm.
12. The composite structure of claim 10 in which the average foil thickness is no more than 4 times that of the diameters of filaments embedded therein.
13. The composite structure of claim 10 in which the volume percent of filament present in the host foil is between 3 and 80%.
14. The composite structure of claim 10 in which the volume percent of filaments present in the host foil is between 20 and 40%.
15. A composite structure comprising a plurality of layers of aligned high strength, high temperature filaments, said filaments being embedded in a host titanium base matrix metal having a density of more than 99%, said host titanium base matrix metal being made up from layers which are consolidated at high temperature and pressure, and the interfaces at which said layers are joined lying generally along tangent lines extending from aligned filaments, said targets lying generally parallel to each other.

Crucible and extrinsic facecoat compositions US20140150986

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK BANCHERI STEPHEN FRANCIS MCKIEVER JOAN ELLIS BRIAN MICHAEL • International Patent Classification B22D-041/02 B28B-001/16 B28B-007/00 B28B-007/28 F27B-014/10 F27D-001/00 • US Patent Classification PCLO=266286000 PCLO=264255000 PCLX=266276000 PCLX=425186000 PCLX=432265000 • CPC Code B28B-001/16; B28B-007/00/02; B28B-007/28; F27B-014/10; F27B-2014/104; F27D-001/00/06 F27D-001/00/06; F27M-2001/01 F27M-2001/01; 	<ul style="list-style-type: none"> • Publication Information US2014150986 A1 2014-06-05 [US20140150986]  • Priority Details 2012US-13693155 2012-12-04 2015US-14628423 2015-02-23 												
<ul style="list-style-type: none"> • Fampat family <table style="margin-left: 20px; border-collapse: collapse;"> <tr> <td style="padding-right: 10px;">US2014150986</td> <td style="padding-right: 10px;">A1</td> <td style="padding-right: 10px;">2014-06-05</td> <td>[US20140150986]</td> </tr> <tr> <td>US8992824</td> <td>B2</td> <td>2015-03-31</td> <td>[US8992824]</td> </tr> <tr> <td>US2015168069</td> <td>A1</td> <td>2015-06-18</td> <td>[US20150168069]</td> </tr> </table> 		US2014150986	A1	2014-06-05	[US20140150986]	US8992824	B2	2015-03-31	[US8992824]	US2015168069	A1	2015-06-18	[US20150168069]
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US8992824	B2	2015-03-31	[US8992824]										
US2015168069	A1	2015-06-18	[US20150168069]										

- **Abstract:**

(US20140150986)

Crucible compositions and methods of using the crucible compositions to melt titanium and titanium alloys. More specifically, crucible compositions having extrinsic facecoats comprising a rare earth oxide that are effective for melting titanium and titanium alloys for use in casting titanium-containing articles. Further embodiments are titanium-containing articles made from the titanium and titanium alloys melted in the crucible compositions. Another embodiment is a crucible curing device and methods of use thereof.

Claims

(US20140150986)

1. A crucible for melting titanium and titanium alloys, said crucible comprising: an extrinsic facecoat having at least one extrinsic facecoat layer comprising a rare earth oxide;

a bulk disposed behind the extrinsic facecoat and comprising a calcium aluminate cement; and

a cavity for melting titanium and titanium alloys therein, said cavity being defined by the exposed surface of the extrinsic facecoat.

2. The crucible as recited in claim 1, wherein the extrinsic facecoat and the bulk have a combined thickness that is substantially uniform in that it does not vary by more than 30 percent throughout the crucible.

3. The crucible as recited in claim 1, wherein the extrinsic facecoat has a thickness of about 10 microns to about 4,000 microns.

4. The crucible as recited in claim 1, wherein the at least one extrinsic facecoat layer comprises about 1% to about 100% by weight of the rare earth oxide.

5. The crucible as recited in claim 1, wherein the rare earth oxide is selected from the group consisting of yttrium oxide, dysprosium oxide, terbium oxide, erbium oxide, thulium oxide, ytterbium oxide, lutetium oxide, gadolinium oxide, and mixtures thereof.

6. The crucible as recited in claim 1, wherein the rare earth oxide is in the form of a composition selected from the group consisting of a rare earth oxide-alumina garnet, a rare earth oxide-alumina perovskite, a rare earth oxide-alumina mullite, and mixtures thereof.

7. The crucible as recited in claim 1, wherein the extrinsic facecoat comprises at least two extrinsic facecoat layers, said at least two extrinsic facecoat layers comprising a primary extrinsic facecoat layer and at least one secondary extrinsic facecoat layer disposed between the primary extrinsic facecoat layer and the bulk.

8. The crucible as recited in claim 7, wherein the primary extrinsic facecoat layer comprises a rare earth oxide, and wherein the at least one secondary extrinsic facecoat layer comprises either a rare earth oxide or a non-rare earth oxide selected from the group consisting of alumina, calcium oxide, silicon oxide, zirconium oxide, and mixtures thereof.

9. The crucible as recited in claim 1, wherein the at least one extrinsic facecoat layer is made from a facecoat slurry comprising the rare earth oxide in powder form in a suspension with a colloid suspension, said colloid suspension comprising a colloid selected from the group consisting of colloidal silica, colloidal alumina, colloidal yttria, and mixtures thereof.

10. The crucible as recited in claim 1, wherein the at least one extrinsic facecoat layer comprises between about 5% to about 95% by weight of fine-scale rare earth oxide particles having a diameter of less than about 50 microns, and between about 20% to about 90% by weight of large-scale rare earth oxide particles having a diameter of more than about 50 microns.

11. The crucible as recited in claim 1, wherein the calcium aluminate cement comprises more than 10% by weight of the bulk.

12. The crucible as recited in claim 1, wherein the calcium aluminate cement of the bulk comprises calcium aluminate particles of less than about 100 microns in diameter.

13. The crucible as recited in claim 1, wherein the calcium aluminate cement of the bulk comprises calcium monoaluminate.

14. The crucible as recited in claim 13, wherein the calcium monoaluminate of the bulk comprises a weight fraction of about 0.05 to 0.95.

15. The crucible as recited in claim 13, wherein the calcium aluminate cement of the bulk further comprises calcium dialuminate, mayenite, or both calcium dialuminate and mayenite.

16. The crucible as recited in claim 15, wherein the calcium dialuminate of the bulk comprises a weight fraction of about 0.05 to about 0.80.

17. The crucible as recited in claim 15, wherein the mayenite of the bulk comprises a weight fraction of about 0.01 to about 0.30.

18. The crucible as recited in claim 1, wherein the bulk further comprises alumina.

19. The crucible as recited in claim 18, wherein the alumina of the bulk comprises from about 10% to about 90% by weight of the bulk.

20. The crucible as recited in claim 18, wherein the alumina of the bulk comprises alumina particles of about 10 microns to about 10 millimeters in diameter.

21. The crucible as recited in claim 1, wherein the bulk comprises from about 10% to about 50% by weight calcium oxide.

22. The crucible as recited in claim 1 further comprising: a bonding layer disposed between the extrinsic facecoat and the bulk, said bonding layer comprising a fine-scale calcium aluminate cement having a particle size of less than 50 microns.

23. The crucible as recited in claim 22, wherein said fine-scale calcium aluminate cement comprises calcium monoaluminate in a weight fraction of about 0.05 to 0.95 of the bonding layer.

24. The crucible as recited in claim 22, wherein said fine-scale calcium aluminate cement comprises mayenite in a weight fraction of about 0.01 to about 0.30 of the bonding layer.

25. The crucible as recited in claim 22, wherein the extrinsic facecoat, the bonding layer, and the bulk have a combined thickness that is substantially uniform in that it does not vary by more than 30 percent throughout the crucible.

26. The crucible as recited in claim 1, wherein the crucible meets thermal shock resistance requirements for melting titanium or titanium alloys for use in a casting mold that forms a titanium-containing article.

27. The crucible as recited in claim 26, wherein the thermal shock resistance requirements for melting the titanium or titanium alloys at a temperature of more than 1500 deg. C., and up to 1750 deg. C. for at least 1 second.

28. The crucible as recited in claim 26, wherein the titanium-containing article comprises a titanium aluminide-containing turbine blade.

29. The crucible as recited in claim 1, further comprising: aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, or mixtures thereof.

30. A method for preparing a crucible for melting titanium and titanium alloys useful in making a titanium-containing article, said method comprising: providing a removable pattern coated with a crucible extrinsic facecoat, wherein the extrinsic facecoat

comprises at least one extrinsic facecoat layer comprising a rare earth oxide;

forming a crucible bulk behind the extrinsic facecoat, wherein the bulk comprises a calcium aluminate cement; and

removing the removable pattern to yield a crucible having a cavity for melting titanium and titanium alloys therein, said cavity being defined by the exposed surface of the extrinsic facecoat,

wherein the extrinsic facecoat and the bulk have a combined thickness that is substantially uniform in that it does not vary by more than 30 percent throughout the crucible.

31. The method as recited in claim 30 further comprising: incorporating a bonding layer between the extrinsic facecoat and the bulk, said bonding layer comprising a fine-scale calcium aluminate cement having a particle size of less than 50 microns.

32. The method as recited in claim 31, wherein the extrinsic facecoat, the bonding layer, and the bulk have a combined thickness that is substantially uniform in that it does not vary by more than 30 percent throughout the crucible.


33. The method as recited in claim 31, further comprising firing the formed crucible, wherein said firing is at a temperature of between about 600 deg. C. and about 1750 deg. C.

34. The method as recited in claim 31, further comprising preheating the crucible and melting titanium or a titanium alloy in the heated crucible to produce molten titanium or molten titanium alloy.

35. The method as recited in claim 31, further comprising pouring the molten titanium or the molten titanium alloy into an investment mold, solidifying the molten titanium or the molten titanium alloy to form a solidified titanium or titanium alloy casting, and removing the solidified titanium or titanium alloy casting from the mold.

Silicon carbide-containing mold and facecoat compositions and methods for casting titanium and titanium aluminide alloys

US20150147186

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor BEWLAY BERNARD PATRICK MCKIEVER JOAN ELLIS BRIAN MICHAEL MCCLASKY NICHOLAS VINCENT • International Patent Classification B22C-001/02 B22C-001/10 B22C-001/18 B22C-009/04 B22C-009/22 B22D-021/06 B22D-025/02 C04B-028/06 C04B-035/057 C04B-035/117 C04B-035/44 C04B-035/565 C04B-035/626 C04B-035/63 C04B-038/08 C04B-111/00 F01D-005/28 • US Patent Classification PCLO=416241000R PCLX=164034000 PCLX=164529000 • CPC Code B22C-001/02; B22C-009/04/3; B22C-009/04; B22C-009/22; B22D-021/06; B22D-025/02; C04B-028/06; C04B-035/057; C04B-035/117; C04B-035/44; C04B-035/565; C04B-035/626/3; C04B-035/63/03; C04B-038/08; C04B-2111/00939; C04B-2235/3208; C04B-2235/3222; C04B-2235/3826; C04B-2235/5436; C04B-2235/6028; C04B-2235/9676; F01D-005/28; Y02T-050/671 	<ul style="list-style-type: none"> • Publication Information US2015147186 A1 2015-05-28 [US20150147186]  • Priority Details 2013US-14090974 2013-11-26 												
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">US2015147186</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">2015-05-28</td> <td style="width: 30%;">[US20150147186]</td> </tr> <tr> <td>WO2015080837</td> <td>A2</td> <td>2015-06-04</td> <td>[WO2015080837]</td> </tr> <tr> <td>WO2015080837</td> <td>A3</td> <td>2015-07-30</td> <td>[WO2015080837]</td> </tr> </table> 		US2015147186	A1	2015-05-28	[US20150147186]	WO2015080837	A2	2015-06-04	[WO2015080837]	WO2015080837	A3	2015-07-30	[WO2015080837]
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WO2015080837	A3	2015-07-30	[WO2015080837]										

- **Abstract:**

(US20150147186)

The disclosure relates generally to mold compositions and methods of molding and the articles so molded. More specifically, the disclosure relates to silicon carbide-containing mold compositions, silicon carbide-containing intrinsic facecoat compositions, and methods for casting titanium-containing articles, and the titanium-containing articles so molded.

Claims

(US20150147186)

1. A method for forming a mold for casting a titanium-containing article, comprising: mixing calcium aluminate and silicon carbide with a liquid to produce a slurry, wherein the percentage of solids in the slurry is about 60% to about 80% by weight of the slurry and a viscosity of the slurry is about 30 to about 1500 centipoise;

introducing the slurry into a mold cavity that contains a fugitive pattern; and

allowing the slurry to cure in the mold cavity to form the mold for casting the titanium-containing article.

2. The method of claim 1, wherein the silicon carbide particles are from about 10 microns to about 50 microns in outside dimension.

3. The method of claim 1, wherein the calcium aluminate comprises more than 20% by weight of the slurry.

4. The method of claim 1, wherein a particle size of the calcium aluminate is less than about 50 microns in outside dimension.

5. The method of claim 1, wherein, the slurry further comprises oxide particles.

6. The method of claim 5, wherein said oxide particles are hollow.

7. The method of claim 5, wherein the oxide particles are selected from a group consisting of aluminum oxide particles, magnesium oxide particles, calcium oxide particles, zirconium oxide particles, titanium oxide particles, silicon oxide particles, and compositions thereof.

8. The method of claim 5, wherein the oxide particles are aluminum oxide particles.

9. The method of claim 8, wherein said aluminum oxide particles comprise from about 30% by weight to about 68% by weight of the slurry.

10. The method of claim 8, wherein said aluminum oxide particles are from about 50 microns to about 1500 microns in outside dimension.

11. The method of claim 1, wherein before introducing the slurry into the mold cavity, large scale hollow oxide particles are added to the slurry to form a final calcium aluminate-liquid cement mixture, such that the solids in the slurry are about 70% to about 95% by weight of the slurry.

12. The method of claim 1, further comprising calcium oxide added such that more than about 10% by weight and less than about 50% by weight of the slurry is calcium oxide.

13. The method of claim 1, wherein the percentage of solids in the slurry is about 60% to about 78%.

14. The method of claim 1, further comprising adding less than 2% silica to the slurry.

15. A method for casting titanium and titanium alloys, comprising: obtaining an investment casting mold composition comprising calcium aluminate and large scale aluminum oxide, wherein the calcium aluminate and alumina are combined with a liquid and silicon carbide to produce a final calcium aluminate/liquid mixture slurry, and wherein the solids in the final mixture is about 70% to about 95% by weight of the slurry;

pouring said investment casting mold composition into a vessel containing a fugitive pattern;

curing said investment casting mold composition;

removing said fugitive pattern from the mold;

firing the mold;

preheating the mold to a mold casting temperature;

pouring molten titanium or titanium alloy into the heated mold;

solidifying the molten titanium or titanium alloy;

forming a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold.

16. The method of claim 15, wherein particles of the aluminum oxide are about 50 microns to about 1500 microns in outside dimension.

17. The method of claim 15, wherein silicon carbide particles are about 10 microns to about 100 microns in outside dimension.

18. The method of claim 15, wherein the silicon carbide is present between 15% to 45% by weight and provides increased thermal conductivity during casting by at least 25% as compared to casting performed without silicon carbide.

19. A turbine blade produced by the process, comprising: providing an investment casting mold, said mold comprising calcium aluminate, silicon carbide and aluminum oxide;

pouring molten titanium or titanium alloy into the mold;

solidifying the molten titanium or titanium alloy;

forming a solidified titanium or titanium alloy casting; and

removing the solidified titanium or titanium alloy casting from the mold to produce the turbine blade, wherein the turbine blade has an average roughness, Ra, of less than 20 across at least a portion of its surface area.

20. The method of claim 19, wherein silicon carbide particles are about 10 microns to about 100 microns in outside dimension.

21. The method of claim 19, wherein the silicon carbide is present between 15% to 45% by weight and provides increased thermal conductivity during casting by at least 25% as compared to casting performed without silicon carbide.

22. A method for manufacturing a turbine component, comprising: making a mold from a mixture comprising calcium aluminate, calcium dialuminate, silicon carbide, mayenite and water, wherein the silicon carbide is present at about 15% to about 45% by weight;

firing the mold;

pouring molten titanium or titanium alloy into the mold;

solidifying the molten titanium or titanium alloy to form a solidified casting; and

removing the casting from the mold.


23. The method of claim 22, further comprising hollow aluminum oxide particles that are larger than about 50 microns.

24. The method of claim 22, wherein silicon carbide particles are about 10 microns to about 100 microns in outside dimension.

25. The method of claim 22, wherein the silicon carbide is present between 15% to 45% by weight and provides increased thermal conductivity during casting by at least 25% as compared to casting performed without silicon carbide.

High-niobium titanium aluminide alloys

IT9022275

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-014/00 C22C-030/00 • US Patent Classification PCLO=420418000 PCLX=148407000 PCLX=148419000 PCLX=148421000 PCLX=148442000 PCLX=420580000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information IT9022275 D0 1990-12-04 [IT9022275] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1989US-07445306 1989-12-04 1991US-07695043 1991-05-02 																																								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <td style="width: 30%;">IT9022275</td> <td style="width: 10%;">D0</td> <td style="width: 20%;">1990-12-04</td> <td style="width: 40%;">[IT9022275]</td> </tr> <tr> <td>GB9024191</td> <td>D0</td> <td>1990-12-19</td> <td>[GB9024191]</td> </tr> <tr> <td>IT9022275</td> <td>A1</td> <td>1991-06-05</td> <td>[IT9022275]</td> </tr> <tr> <td>CA2025272</td> <td>A1</td> <td>1991-06-05</td> <td>[CA2025272]</td> </tr> <tr> <td>DE4037959</td> <td>A1</td> <td>1991-06-06</td> <td>[DE4037959]</td> </tr> <tr> <td>FR2655353</td> <td>A1</td> <td>1991-06-07</td> <td>[FR2655353]</td> </tr> <tr> <td>GB2238794</td> <td>A</td> <td>1991-06-12</td> <td>[GB2238794]</td> </tr> <tr> <td>JPH03183737</td> <td>A</td> <td>1991-08-09</td> <td>[JP03183737]</td> </tr> <tr> <td>US5089225</td> <td>A</td> <td>1992-02-18</td> <td>[US5089225]</td> </tr> <tr> <td>IT1243408</td> <td>B</td> <td>1994-06-10</td> <td>[IT1243408]</td> </tr> </table> 		IT9022275	D0	1990-12-04	[IT9022275]	GB9024191	D0	1990-12-19	[GB9024191]	IT9022275	A1	1991-06-05	[IT9022275]	CA2025272	A1	1991-06-05	[CA2025272]	DE4037959	A1	1991-06-06	[DE4037959]	FR2655353	A1	1991-06-07	[FR2655353]	GB2238794	A	1991-06-12	[GB2238794]	JPH03183737	A	1991-08-09	[JP03183737]	US5089225	A	1992-02-18	[US5089225]	IT1243408	B	1994-06-10	[IT1243408]
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- **Abstract:**

(US5089225)

A TiAl composition is prepared by ingot metallurgy to have higher strength and to have moderately reduced or improved ductility by altering the atomic ratio of the titanium and niobium to have what has been found to be a highly desirable effective aluminum concentration and by addition of niobium according to the approximate formula Ti₄₈₋₃₇ Al₄₆₋₄₉ Nb₆₋₁₄.

Claims

(US5089225)

What is claimed is:

1.

An aged niobium modified titanium aluminum alloy,
said alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:
said alloy having been prepared by ingot metallurgy.

2. An aged niobium modified titanium aluminum alloy,

said alloy consisting essentially of titanium, aluminum, and niobium in the atomic ratio of:
said alloy having been prepared by ingot metallurgy.

3. An aged niobium modified titanium aluminum alloy,

said alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:
said alloy having been prepared by ingot metallurgy.

4. A niobium modified titanium aluminum alloy,

said alloy consisting essentially of titanium, aluminum, and niobium in the atomic ratio:
said alloy having been prepared by ingot metallurgy.

5. A niobium modified titanium aluminum alloy,

said alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:
said alloy having been prepared by ingot metallurgy.

6. As an article of manufacture, a structural member,

said member being formed of an aged niobium modified titanium aluminum alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:

said alloy having been prepared by ingot metallurgy.

7. As an article of manufacture, a structural member,

said member being formed of an aged niobium modified titanium aluminum alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:

said alloy having been prepared by ingot metallurgy.

8. As an article of manufacture, a structural member,

said member being formed of an aged niobium modified titanium aluminum alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:

said alloy having been prepared by ingot metallurgy.

9. As an article of manufacture, a structural member,

said member being formed of a niobium modified titanium aluminum alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:


said alloy having been prepared by ingot metallurgy.

10. As an article of manufacture, a structural member,

said member being formed of a niobium modified titanium aluminum alloy consisting essentially of titanium, aluminum, and niobium in the following atomic ratio:

said alloy having been prepared by ingot metallurgy.

Method for heat treating gamma titanium aluminide alloys US5634992

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor KELLY THOMAS J WEIMER MICHAEL J AUSTIN CURTISS M FINK PAUL J HUANG SHYH-CHIN • International Patent Classification C22F-001/18 • US Patent Classification PCLO=148669000 PCLX=148671000 • CPC Code C22F-001/18/3 	<ul style="list-style-type: none"> • Publication Information US5634992 A 1997-06-03 [US5634992] <div style="text-align: right; margin-top: 5px;">  </div> <ul style="list-style-type: none"> • Priority Details 1994US-08262178 1994-06-20 1996US-08656728 1996-06-03
<ul style="list-style-type: none"> • Fampat family US5634992 A 1997-06-03 [US5634992] 	

- **Abstract:**

(US5634992)

A gamma titanium aluminide alloy article is produced from a piece of cast gamma titanium aluminide alloy by consolidating the gamma titanium aluminide alloy piece at a temperature above the eutectoid to reduce porosity therein, preferably by hot isostatic pressing. The piece is first heat treated at a temperature above the eutectoid for a time sufficient to form a structure of gamma grains plus lamellar colonies of alpha and gamma phases, and thereafter second heat treated at a temperature below the eutectoid to grow gamma grains within the colony structure, thereby reducing the effective grain size of the colony structure. There may follow an additional heat treatment just below the alpha transus to reform any remaining colony structure to produce a structure having isolated alpha-two laths within gamma grains.

Claims

(US5634992)

What is claimed is:

1.

A method producing a gamma titanium aluminide alloy article, comprising the steps of:

providing a piece of cast gamma titanium aluminide alloy having a composition capable of forming alpha, alpha-2, and gamma phases, and a eutectoid in which alpha phase decomposes to colonies comprising alpha-2 and gamma phase upon cooling, the piece of cast gamma titanium aluminide alloy having an aluminum content of from about 45.5 to about 48.5 atomic percent
consolidating the gamma titanium aluminum alloy piece at a temperature above the eutectoid to reduce porosity therein;
first heat treating the gamma titanium aluminide piece at a temperature above the eutectoid for a time sufficient to form a structure of gamma grains plus lamellar colonies comprised of alpha-2 and gamma phases, wherein the step of first heat treating includes the steps of heating the piece to a temperature of from about 2100 (degree) F. to about 2200 (degree) F. for a time of at least 8 hours;

and thereafter

second heat treating the gamma titanium aluminide piece at a temperature below the eutectoid to grow gamma grains within the colony structure, thereby reducing the effective grain size of the colony structure, wherein the step of second heat treating includes the step of heating the piece to a temperature of from about 1800 (degree) F. to about 2000 (degree) F. for a time of at least about 8 hours.

2. The method of claim 1, wherein the step of providing includes the step of

hot isostatic pressing the piece at a temperature above the eutectoid.

3. The method of claim 2, wherein the step of hot isostatic pressing includes the step of heating the piece to a temperature of from about 2200 (degree) F. to about 2300 (degree) F. with an applied hydrostatic pressure.

4. The method of claim 1, further including an additional step, after the step of the second heat treating, of

third heat treating the piece at a temperature of from about 2300 (degree) F. to about 2450 (degree) F. for a time of from about 1/2 hour to about 8 hours.

5. A method of producing a gamma titanium aluminide alloy article, comprising the steps of:

providing a piece of cast gamma titanium aluminum alloy having a composition capable of forming alpha, alpha-2, and gamma phases, and having a eutectoid in which the alpha phase decomposes to alpha-2 and gamma phases upon cooling, the piece of the cast gamma titanium aluminide alloy having an aluminum content of from about 45.5 to about 48.5 atomic percent;
consolidating the piece at a temperature above the eutectoid to reduce porosity therein;

and

first heat treating the piece at a temperature of about 25 (degree) F. to about 75 (degree) F. above the eutectoid for a time of at least about 8 hours;

and thereafter

second heat treating the piece at a temperature of from about 100 (degree) F. to about 300 (degree) F. below the eutectoid for a time of at least about 8 hours.

6. The method of claim 5, wherein the step of consolidating includes the step of

hot isostatic pressing the piece at a temperature above the eutectoid.

7. The method of claim 6, wherein the step of hot isostatic pressing includes the step of heating the piece to a temperature of from about 2200 (degree) F. to about 2300 (degree) F. with an applied hydrostatic pressure.

8. The method of claim 5, wherein the step of first heat treating includes the step of

heating the piece to a temperature of from about 2100 (degree) F. to about 2200 (degree) F. for a time of at least about 8 hours.


9. The method of claim 5, wherein the step of second heat treating includes the step of

heating the piece to a temperature of from about 1800 (degree) F. to about 2000 (degree) F. for a time of at least about 8 hours.

10. The method of claim 5, further including an additional step, after the step of second heat treating, of

third heat treating the piece at a temperature of from about 2300 (degree) F. to about 2450 (degree) F. for a time of from about 1/2 hours to about 8 hours.

Method for directional solidification casting of a titanium aluminide. EP-530968

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification B22D-021/00 B22D-027/04 C22C-014/00 C22C-021/00 C30B-011/00 C30B-028/06 • CPC Code B22D-027/04; C22C-021/00 	<ul style="list-style-type: none"> • Publication Information EP0530968 A1 1993-03-10 [EP-530968] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1991US-07738759 1991-08-29 								
<ul style="list-style-type: none"> • Fampat family <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">EP0530968</td> <td style="width: 20%;">A1</td> <td style="width: 20%;">1993-03-10</td> <td style="width: 30%;">[EP-530968]</td> </tr> <tr> <td>JPH05200529</td> <td>A</td> <td>1993-08-10</td> <td>[JP05200529]</td> </tr> </table> 		EP0530968	A1	1993-03-10	[EP-530968]	JPH05200529	A	1993-08-10	[JP05200529]
EP0530968	A1	1993-03-10	[EP-530968]						
JPH05200529	A	1993-08-10	[JP05200529]						

- **Abstract:**

(EP-530968)


A method for directional solidified vacuum or protective atmosphere casting of gamma titanium aluminide alloys in a mold comprised of a chill and a sidewall means extending from the chill to form a cavity for holding a molten metal, the method comprising, forming a melt of the gamma titanium aluminide alloy in the cavity, the melt being comprised of a metal from the group consisting of niobium, tantalum, tungsten, and molybdenum in an effective amount to reduce oxygen pickup in the melt, the sidewall means having at least an inner liner of a calcia refractory facing the melt. The melt is heated in a thermal gradient sufficient to cause directional solidification of the melt from the chill. (see diagramm 1 page 0)

Claims

(EP-530968)

1. A method for directional solidification vacuum or protective atmosphere casting a gamma titanium aluminide alloy in a mold comprised of a chill and a sidewall means extending from the chill to form a cavity for holding a molten metal, comprising:
 - forming a melt of the gamma titanium aluminide alloy in the cavity, the melt being comprised of a metal from the group consisting of niobium, tantalum, tungsten, and molybdenum in an effective amount to reduce oxygen pickup in the melt, the sidewall means having at least an inner liner of a calcia refractory facing the melt;
 - and
 - heating the melt in a thermal gradient sufficient to cause directional solidification of the melt from the chill.
2. A method according to claim 1 wherein the metal is niobium.
3. A method according to Claim 1 or Claim 2 wherein an effective amount is about 2 to 12 atom percent.
4. A method according to any preceding claim wherein an effective amount is about 4 to 8 atom percent.
5. A method for directional solidification casting a gamma titanium aluminide alloy in a non-oxidizing atmosphere or vacuum and in a mold comprised of a chill and a sidewall means extending from the chill to form a cavity for holding a molten metal, the method comprising:
 - forming the sidewall means to have at least an inner liner of a calcia refractory adjacent the melt;
 - forming a melt of the gamma titanium aluminide alloy in the mold, the melt being comprised of an effective amount of niobium to reduce oxygen pickup in the melt;
 - and
 - heating the melt in a thermal gradient sufficient to cause directional solidification of the melt from the chill.
6. A method according to claim 5 wherein the metal is niobium.
7. A method according to Claim 5 or Claim 6 wherein an effective amount is about 2 to 12 atom percent.
8. A method according to any one of Claims 5 to 7 wherein an effective amount is about 4 to 8 atom percent.

Single phase TiAl alloy modified by tantalum US5492574

<ul style="list-style-type: none"> • Patent Assignee GENERAL ELECTRIC • Inventor HUANG SHYH-CHIN • International Patent Classification C22C-014/00 • US Patent Classification PCLO=148421000 PCLX=148670000 PCLX=420418000 PCLX=420421000 • CPC Code C22C-014/00 	<ul style="list-style-type: none"> • Publication Information US5492574 A 1996-02-20 [US5492574] <div style="text-align: right;">  </div> <ul style="list-style-type: none"> • Priority Details 1994US-08309701 1994-09-21
<ul style="list-style-type: none"> • Fampat family US5492574 A 1996-02-20 [US5492574] 	

- **Abstract:**
(US5492574)
The present invention comprises a plurality of single phase gamma TiAl alloys modified by Ta. These alloys comprise Ti(45-46)Al(50-51)Ta4 in atomic percent, and exhibit significant room temperature ductility, in the range of 1.3-2.1% tensile elongation. The alloys may be made by the use of cast and forging techniques.

Claims

(US5492574)

What is claimed is:

1.

A tantalum modified titanium aluminum alloy consisting essentially of titanium, aluminum and tantalum in the following approximate atomic ratio:

said alloy having a single phase gamma microstructure.

2. The alloy of claim 1, said alloy having a ductility as measured by tensile elongation in the range of 1.3-2.2 percent.

3. The alloy of claim 1 having a tensile strength of 49 ksi or greater.

4. The alloy of claim 1, wherein said alloy has a yield strength of 38 ksi or greater.

5. A tantalum modified titanium aluminum alloy consisting essentially of titanium, aluminum and tantalum in the following approximate atomic ratio:

said alloy having been formed by a method of casting and forging, and wherein said alloy is homogenized prior to forging.

6. The alloy of claim 5, wherein said alloy is heat treated after forging at a temperature in the range of 1300-1375 (degree) C.

7. The alloy of claim 5, wherein the alloy is homogenized at a temperature in the range of 1250-1400 (degree) C.

8. The alloy of claim 7, wherein said alloy is a single phase gamma alloy.

9. The alloy of claim 8, wherein said alloy has a ductility as measured by tensile elongation in the range of 1.3-2.2 percent.

10. The alloy of claim 5, wherein the homogenization temperature is in the range of 1250-1400 (degree) C.