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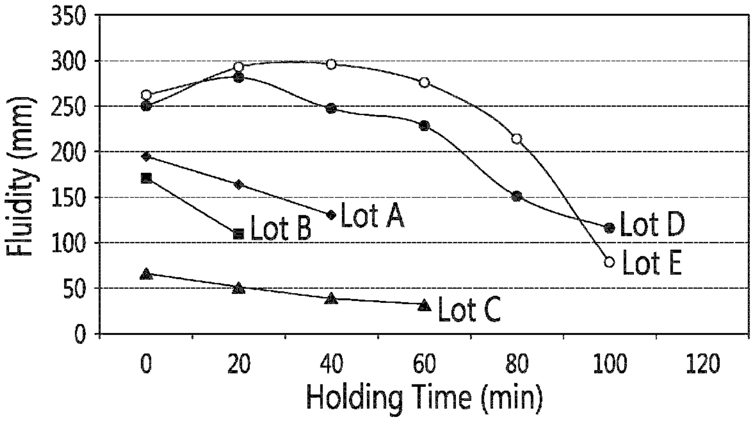

FIG. 1

(57) **Abstract**: The present disclosure provides additives capable of undergoing a peritectic reaction with boron in aluminum-boron carbide composite materials. The additive may be selected from the group consisting of vanadium, zirconium, niobium, strontium, chromium, molybdenum, hafnium, scandium, tantalum, tungsten and combination thereof, is used to maintain the fluidity of the molten composite material, prior to casting, to facilitate castability.

ADDITIVES FOR IMPROVING THE CASTABILITY OF ALUMINUM-BORON CARBIDE COMPOSITE MATERIAL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. provisional patent application 61/727,949 filed on November 19, 2012 and herewith incorporated in its entirety.

TECHNOLOGICAL FIELD

The present invention relates to cast aluminum/boron carbide composite metal matrix material having products obtained from a peritectic reaction to increase their fluidity prior to casting. The reaction products are obtained by using additives capable of undergoing a perictectic reaction with the boron of the boron carbide.

BACKGROUND

To increase the fluidity of the molten AI-B_4C mixture, and as described in U.S. patent Serial No. 7,562,962, titanium can be added. When titanium is added to the mixture of molten aluminum metal and B_4C powder, reaction products are formed near the interface of the B_4C particles and the aluminum matrix which "poison" the B_4C particles. The reaction products are taught to shield the B_4C particles from the aluminum.

It would be highly desirable to be provided with means and methods of maintaining a proper fluidity of a molten AI-B_4C mixture prior to casting and shaping. The means and methods would preferably provide/maintain a fluidity amenable to shaping and/or casting in industrial settings.

BRIEF SUMMARY

The present disclosure provides a cast composite material comprising aluminum, products of a peritectic reaction between an additive and boron as well as dispersed boron carbide particles. The presence of the products of the peritectic reaction maintains the fluidity of the molten composite material, prior to casting, and facilitate castability and shaping of the composite material.

In a first aspect, the present disclosure provides a cast composite material comprising (i) aluminum, (ii) products of a peritectic reaction between an additive and boron, (iii) dispersed boron carbide particles and (iv) optionally titanium. The additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof. A sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°. In an embodiment, the cast length of the sample is at least 190 mm. In another embodiment, the cast composite material is submitted to holding during a holding time and to casting during a casting time and wherein the holding time and the casting time amounts to 120 minutes. In another embodiment, the products of the peritectic reaction are provided by combining a molten aluminum or a molten aluminum alloy with the additive capable of undergoing the peritectic reaction (prior to the incorporation of boron carbide particles). In yet a further embodiment, the additive is selected from the group consisting of zirconium, strontium, scandium and any combination thereof. In another embodiment, the additive is scandium. In a further embodiment, the additive is strontium. In yet a further embodiment, the additive is zirconium. In an embodiment, the concentration (v/v) of the dispersed boron carbide particles is between 4% and 40% with respect to the total volume of the cast composite material. In such embodiment, the concentration (w/w) of the additive can be between 0.47% and 8.00% with respect to the total weight of the cast composite material and optionally, the composite material can further comprise titanium at a concentration (w/w) between 0.50% and 4.00% with respect to the total weight of the cast composite material. In another embodiment, the concentration (v/v) of the dispersed boron carbide particles is between 4.5% and 18.9% with respect to the total volume of the cast composite material. In such embodiment, the concentration (w/w) of the additive can be between 0.38% and 4.00% with respect to the total weight of the cast composite material and, optionally, the cast composite material further comprises titanium at a concentration (w/w) between 0.40% and 2.00% with respect to the total weight of the cast composite material. In another embodiment, the concentration (v/v) of the dispersed boron carbide particles is between 19.0% and 28.0% with respect to the total volume of the cast composite material. In such embodiment, the concentration (w/w) of the additive can be between 1.68% and 6.00% with respect to the total weight of the cast composite material and, optionally, the cast composite material can further comprise titanium at a concentration (w/w) between 1.80% and 3.00% with respect to the total weight of the cast composite material. In still another embodiment, the concentration (v/v) of the dispersed boron carbide particles is between 25.0% and 28.0% or between 28.0% and 33.0% with respect to the total volume of the cast composite material. In such embodiment, the concentration (w/w) of the additive can be between 0.94% and 4.00% with respect to the total weight of the cast composite material and, optionally, the cast composite material can further comprise titanium at a concentration (w/w) between 1.00% and 2.00% with respect to the total weight of the cast composite material.

According to a second aspect, the present disclosure provides a method of preparing a cast composite material. Broadly the method comprises (a) combining (i) a molten aluminum alloy comprising an additive capable of undergoing a peritectic reaction with boron with (ii) a source of boron carbide particles so as to provide a molten composite material comprising products of the peritectic reaction between the additive and boron and dispersed boron carbide particles and (b) casting the molten composite so as to form the cast composite material. The additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof. A sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°. In an embodiment, the cast length is at least 190 mm. In still another embodiment, the method further comprises, prior to step (b), holding the molten composite material during a holding time and casting the molten composite during a casting time, wherein the holding time and the casting time amounts to 120 minutes. In still another embodiment, the method further comprises, prior to step (a), providing the molten aluminum alloy by combining a molten aluminum or a molten aluminum alloy with the additive capable of undergoing the peritectic reaction. Embodiments with respect to the type of additives that can be used, the concentration of the additives, the concentration of the boron carbide particles, the optional presence of titanium in the composite material have been described above and do apply herein.

According to a third aspect, the present disclosure provides a method of improving the casting and/or shaping properties of a molten composite material comprising aluminum, products of a peritectic reaction between an additive and boron, and dispersed boron carbide particles. Broadly, the method comprises combining (i) a molten aluminum alloy comprising the additive capable of undergoing a peritectic reaction with boron with (ii) a source of boron carbide particles so as to provide a molten composite material. The additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof. A sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°. Embodiments with respect to the cast length, the type of additives that can be used, the concentration of the additives, the concentration of the boron carbide particles, the optional presence of titanium in the composite material have been described above and do apply herein.

According to a fourth aspect, the present disclosure provides a method of facilitating shaping of a molten composite material of a molten composite material comprising aluminum, products of a peritectic reaction between an additive and boron, and dispersed boron carbide particles.

Broadly, the method comprises combining (i) a molten aluminum alloy comprising the additive capable of undergoing a peritectic reaction with boron with (ii) a source of boron carbide particles so as to provide a molten composite material. The additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof. A sample of the composite material having a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°. Embodiments with respect to the cast length, the type of additives that can be used, the concentration of the additives, the concentration of the boron carbide particles, the optional presence of titanium in the composite material have been described above and do apply herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawing in which:

Figure 1 shows the loss of fluidity of molten aluminum mixture containing different lots of B_4C powder. Results are shown as fluidity (as measured as a cast length (in mm) of sample measured using a K-mold) in function of holding time in the furnace (in min) for various lots (A to E) of B_4C powders (30% v/v) added to molten aluminum at an initial temperature of 735°C. Results are shown for lot A containing 3.5% w/w Ti (♦), lot B containing 3.5% w/w Ti (■), lot C containing 3.5% w/w Ti (▲), lot D containing 3.0% w/w Ti (•) and lot E containing 2.0 % Ti w/w (°).

Figure 2 illustrates an embodiment of a K-mold that can be used for determining the cast length of the composite material. (A) Schematic side elevation view of the lower inclined portion 10 of the K-mold. (B) Schematic top elevation view of the groove-containing portion 40 of the K-mold. (C) Schematic cross-sectional view of the groove-containing portion 50 of the K-mold.

DETAILED DESCRIPTION

The fabrication of boron metal matrix composites (MMC) with high B_4C content (e.g., for example at least 30% v/v) usually requires B_4C powder of exceptional quality. High quality B_4C powders have a good granulometric distribution and have a minimum of fine powder-like particles. Generally, only such B_4C powder may be incorporated in high amounts into the metal matrix. When the B_4C powder is not of such good quality, significant losses of fluidity during the holding time of the molten metal, i.e. prior to casting, can be observed. In addition, increasing the holding temperature of the molten metal does not compensate for this loss of fluidity because this can favor the reaction between the aluminum and the B_4C powder thereby further increasing the viscosity (loss of fluidity). In such circumstances, the molten metal behaves as a thixotropic material.

Figure 1 shows the loss of fluidity during the holding time of a molten composite, prior to casting. In industrial settings, a certain fluidity is required for a certain amount of time for allowing the shaping/casting of the AI-B_4C mixture. The curves shown in Figure 1 show that the B_4C powder used in the preparation of the composite material increased the viscosity of the material and failed to meet the fluidity required in industrial settings for subsequent steps (shaping for example), even in the presence of titanium.

In accordance with the present disclosure, there is provided a cast AI-B_4C composite material comprising aluminum, products of a peritectic reaction and dispersed boron carbide particles. The composite material is obtained by first combining aluminum (or an aluminum alloy) with an additive (or a combination of additives) capable of undergoing a peritectic reaction with the boron of the boron carbide particles and ultimately provide products of such peritectic reaction in the aluminum or the aluminum alloy. Once the additive has been included in the aluminum (or in the aluminum alloy), boron carbide particles are combined with the aluminum (or the aluminum alloy), thereby causing the peritectic reaction between the additive and the boron. As shown herein, the use of the additive in the aluminum/aluminum alloy (and, ultimately the presence of peritectic reaction products in the composite material) has been shown useful for maintaining the fluidity of the molten composite and as such imparts good castability to a molten composite material. In some embodiments, it is believed that the use of the additive inhibits or slows down the formation of reaction products occurring during holding of the molten composite (such as, for example, the reaction products occurring between Al and B_4C or between Al and B_4C). In other embodiments, it has been shown that the additives can be used to limit the use of titanium in such composite materials without altering substantially their fluidity. This maintenance in fluidity of the molten composite material can allow for the lengthening of the holding time of the molten mixture in the furnace, for using a lower grade of B_4C source as well as for facilitating shaping and/or casting of the resulting metal matrix composite(s).

Prior to being casted, the composite material is in a molten state and has a fluidity. In the disclosure described herein, the molten composite material has, prior to casting, a fluidity which permits casting in an industrial setting. In other to determine the fluidity of a molten composite material, it is possible to use a K-mold. Such mold, currently used and known in the art, measures the length of a sample of the composite material before it solidifies. The length measured with a K-mold is referred to as a cast length.

An embodiment of a K-mold that can be used to determine the fluidity of a sample of a molten composite material is shown in Figure 2. A K-mold is usually composed of two engageable portions, a lower inclined portion 010 (as shown in Figure 2A) and a groove-containing portion 040 (as shown in Figures 2B and 2C). When the sample is inserted in the mold, the inclined portion 010 is engaged with the groove-containing portion 040. The sample is allowed to cast along the inclined portion 010 and within the groove 040 until it sets. The length covered by the sample, usually measured in millimeters, is a measure of fluidity and refers to a cast length.

As shown on Figure 2A, the lower inclined portion is usually monolithic and comprises a plane 015 having a smooth surface and being downwardly inclined from an horizontal axis 020 by an angle 030 of about 10°. The plane 015 is for contacting directly the external sides 055 of the groove-containing portion 040 (shown on Figures 2B and 2C) and for providing an angle to the groove of about 10°.

The groove-containing portion 040 is a partially hollowed structure defining an enclosable groove 050 for containing the sample of the molten composite (Figure 2B). As shown on Figure 2B, the groove-containing portion has external sides 055 for contacting directly the plane 015 of the inclined portion 010. In the embodiment shown in Figure 2B, the groove 050 contains two different sections: sections 060 and sections 070 (defining a protuberance). In some embodiments, the K-mold comprises at least four sections 070 (e.g., four protuberances) located at a distance of 93 mm, 130 mm, 168 mm and 205 mm from the start of the mold (e.g., the position at which the sample starts contacting the inclined plane 015).

Figure 2C shows an enlarged of the enclosable groove 050. The sections 060 have a similar height 061 of about 6.5 mm. The height 061 is constant between the length defined by the external walls 055. The height 061 is measured with respect to the axis 080 defined by the inclined plane 015 (when the groove-containing portion 040 is engaged with the inclined portion 010). The sections 070 also have a similar height 071 of about 4 mm. The height 071 is constant between the length defined by the external walls 055. The height is measured with respect to the axis 080 defined by the inclined plane 015 (when the groove-containing portion 040 is engaged on the inclined portion 010).

In the context of the present disclosure, the cast composite material has a fluidity, preferably prior to casting, corresponding to a cast sample length of at least 100 mm, at least 120 mm, at least 140 mm, at least 160 mm, at least 180 mm, at least 190 mm or at least 200 mm. The sample used for determining the fluidity of the composite material can be heated at a temperature of about 700°C and for about 120 min to reproduce the industrial casting settings.

Thus, the present disclosure also provides a method of manufacturing a cast composite material. In order to do so, a molten aluminum alloy (also referred to as an aluminum-base matrix alloy) comprising the additive (or a combination of additives) capable of undergoing the peritectic reaction is combined with a source of boron carbide to provide a molten composite. As shown in the present disclosure, the fluidity of the molten composite can be maintained at acceptable industrial levels for a longer period of time when compared to a similar molten composite which lacks the additive.

In the methods described herein, the aluminum or the aluminum alloy used is provided in a molten form. As such, the aluminum or the aluminum alloy is preferably heated to its melting temperature prior to its combination with the B_4C particles. In an embodiment, the aluminum alloy comprises (in embodiments consists essentially of and, in further embodiments, consists of) an additive capable of undergoing the peritectic reaction, the remainder being essentially aluminum or an aluminum alloy.

Unavoidable or inevitable impurities (at the most 0.05 % w/w for each impurity) can also be present in the alloy (for a total of impurities of at most 0.15% w/w). Exemplary aluminum alloys include, but are not limited to, alloys from the 11xx series and from the 6xxx series. In some embodiments, Ti can be included in the aluminum or the aluminum alloy. In an alternative embodiment, if Ti is present in the aluminum or the molten aluminum alloy, it is considered to be a trace element (e.g. its concentration does not exceed the concentration of inevitable impurities).

In an embodiment, the composite material comprises between 4% and 40% (v/v) of B_4C particles and the molarity of the additive (or the combination of additives) in the composite material is between 0.01044 and 0.08351. In some embodiments, when Ti is present in the composite material, the combined molarity of the additive (or the combination of additives) and Ti is between 0.01044 and 0.08351. In some embodiments, the concentration of the additive in the composite material can be between 0.47% to 15.32%, 0.47% to 8.00%, 0.90% to 8.00%, 0.95% to 8.00%, 1.00% to 8.00% or 1.10% to 8.00% with respect to the total weight of the composite material (comprising the B_4C particles). In some embodiments, the combined concentration of the additive and Ti in the composite can be between 0.47% to 15.32%, 0.47% to 8.00%, 0.90% to 8.00%, 0.95% to 8.00%, 1.00% to 8.00% or 1.10% to 8.00% with respect to the total weight of the composite material (comprising the B_4C particles).

In another embodiment, the composite material comprises between 4.5% and 18.9% (v/v) of B_4C particles and the molarity of the additive (or the combination of additives) in the composite material is between 0.00835 and 0.04175. In some embodiments, when Ti is present in the composite material, the combined molarity of the additive (or the combination of additives) and Ti is between 0.00835 and 0.04175. In some embodiments, the concentration of the additive in the composite material can be between 0.38% to 7.68%, 0.38% to 4.00%, 0.90% to 4.00%, 0.95% to 4.00%, 1.00% to 4.00% or 1.10% to 4.00% with respect to the total weight of the composite material (comprising the B_4C particles). In some embodiments, the combined concentration of the additive and Ti in the composite can be between 0.38% to 7.68%, 0.38% to 4.00%, 0.90% to 4.00%, 0.90% to 4.00%, 1.00% to 4.00% or 1.10% to 4.00% with respect to the total weight of the composite material (comprising the B_4C particles).

In a further embodiment, the composite material comprises between 19% and 28% (v/v) of B_4C particles and the molarity of the additive (or the combination of additives) in the composite material is between 0.03758 and 0.06263. In some embodiments, when Ti is present in the composite material, the combined molarity of the additive (or the combination of additives) and Ti is between 0.03758 and 0.06263. In some embodiments, the concentration of the additive in the composite material can be between 1.69% to 11.51 % or 1.69% to 6.00% with respect to the total weight of the composite material (comprising the B_4C particles). In some embodiments, the combined concentration of the additive and Ti in the composite can be between 1.69% to 11.51 % or 1.69% to 6.00% with respect to the total weight of the composite material (comprising the B_4C particles).

In a further embodiment, the composite material comprises between 25% and 28% (v/v) or between 28% and 33% (v/v) of B_4C particles and the molarity of the additive (or the combination of additives) in the composite material is between 0.02088 and 0.04175. In some embodiments, when Ti is present in the composite material, the combined molarity of the additive (or the combination of additives) and Ti is between 0.02088 and 0.04175. In some embodiments, the concentration of the additive in the composite material can be between 0.94% to 7.68%, 0.94% to 4.00%, 0.95% to 4.00%, 1.00% to 4.00% or 1.10% to 4.00% with respect to the total weight of the composite material (comprising the B_4C particles). In some embodiments, the combined concentration of the additive and Ti in the composite can be between 0.94% to 7.68%, 0.94% to 4.00%, 0.95% to 4.00%, 1.00% to 4.00% or 1.10% to 4.00% with respect to the total weight of the composite material (comprising the B_4C particles).

The concentration of the additive, provided at a weight percent concentration or at a certain molarity, whether with reference to the aluminum alloy or the total composite material, is to be understood to include all forms of the additives (including soluble additive, excess additive that comes out of solution as intermetallics or refractory compounds, as well additive included in a B-containing peritectic reaction product). The additive capable of causing the formation of a peritectic reaction's product can be added in any convenient form, including master alloy (for example an AI-10% additive master alloy) or as additive-containing granules or powders. In some embodiments, it can be contemplated to add the additive as a form of a powder to wrought alloys (including AAlxxx, AA2xxx, AA3xxx, AA4xxx or AA6xxx) or casting alloys (including AA2xx or AA3xx).

Similarly, the titanium concentration or molarity given in the foregoing description, whether with reference to the aluminum alloy or the total composite material, represent titanium in all forms (including soluble Ti, excess Ti coming out of solution as intermetallics or refractory compounds, as well Ti-B compounds). The titanium can be added in any convenient form, including master alloy (for example an AI-10% Ti master alloy) or as titanium containing granules or powders. In some embodiments, it may be advisable to use an AAIxxx alloy containing titanium in the aluminum alloy. In alternative or complementary embodiments, it can be contemplated to add a titanium as an aluminum alloy such as, for example, wrought alloys (including AA2xxx, AA3xxx, AA4xxx or AA6xxx), or casting alloys (including AA2xx or AA3xx).

In some embodiments, the additive capable of causing the formation of a peritectic reaction's product can be zirconium and the aluminum alloy can comprises or contains zirconium. In some embodiments, when Zr is used as an additive, the composite material does not comprise Ti (if present, Ti is considered to be a trace element). In other embodiments, when Zr is used as an additive, Ti can be present in the composite material. In a composite material comprising between 4% and 40% (v/v) of B_4C particles, zirconium can be provided at a concentration of between about 0.95 to about 7.61, between about 1.00 to about 7.61 or between about 1.10 to about 7.61 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In such embodiment, when Ti is present, it can be provided at a concentration of between about 0.50 to about 4.00, between about 0.90 to about 4.00, between about 0.95 to about 4.00, between about 1.00 to about 4.00 or between about 1.10 to about 4.00 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 4.5% and 18.9% (v/v) of B_4C particles, zirconium can be provided at a concentration of between about 0.76 to about 3.81, between about 0.90 to about 3.81 , between about 0.95 to about 3.81, between about 1.00 to about 3.81 or between about 1.10 to about 3.81 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In such embodiment, when Ti is present, it can be provided at a concentration of between about 0.40 to about 2.00, between about 0.90 to about 2.00, between about 0.95 to about 2.00, between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 19% and 28% (v/v) of B_4C particles, zirconium can be provided at a concentration of between about 3.43 to about 5.71 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In such embodiment, when Ti is present, it can be provided at a concentration of between about 1.80 to about 3.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 25% and 28% (v/v) or 28% and 33% of B_4C particles, zirconium can be provided at a concentration of between about 1.90 to about 3.81 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In such embodiment, when Ti is present, it can be provided at whereas titanium can be provided at a concentration between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. It will be understood that the zirconium concentrations given in the foregoing description, whether with reference to the aluminum alloy or the total composite material, represent zirconium in all forms (including soluble Zr, excess Zr coming out of solution as intermetallics or refractory compounds, as well Zr-B compounds). The zirconium can be added in any convenient form, including master alloy (for example an AI-10% Zr master alloy) or as zirconium containing granules or powders. In some embodiments, it may be advisable to use an AAlxxx alloy containing zirconium in the aluminum alloy. In alternative or complementary embodiments, it can be contemplated to add a zirconium as an aluminum alloy such as, for example, wrought alloys (including AA2xxx, AA3xxx, AA4xxx or AA6xxx), or casting alloys (including AA2xx or AA3xx).

In some embodiments, the additive capable of causing the formation of a peritectic reaction's product can be strontium and the aluminum alloy can comprises or contains strontium in combination with titanium. In a composite material comprising between 4% and 40% (v/v) of B_4C particles, strontium can be provided at a concentration of between about 0.91 to about 7.32, between about 0.95 to about 7.32, between about

1.00 to about 7.32 or between about 1.10 to about 7.32 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration of between about 0.50 to about 4.00, between about 0.90 to about 4.00, between about 0.95 to about 4.00, between about 1.00 to about 4.00 or between about 1.10 to about 4.00 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 4.5% and 18.9% (v/v) of B_4C particles, strontium can be provided at a concentration of between about 0.73 to about 3.66, between about 0.90 to about 3.66, between about 0.95 to about 3.66, between about 1.00 to about 3.66 or between about 1.10 to about 3.66 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration of between about 0.40 to about 2.00, between about 0.90 to about 2.00, between about 0.95 to about 2.00, between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 19% and 28% (v/v) of B_4C particles, strontium can be provided at a concentration of between about 3.29 to about 5.49 weight percentage with respect to the composite material (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration between about 1.80 to about 3.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 25% and 28% (v/v) or between 28% and 33% of B_4C particles, strontium can be provided at a concentration of between about 1.83 to about 3.66 weight percentage with respect to the composite material (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. It will be understood that the strontium concentrations given in the foregoing description, whether with reference to the aluminum alloy or the total composite material, represent strontium in all forms (including soluble Sr, excess Sr coming out of solution as intermetallics or refractory compounds, as well Sr-B compounds). The strontium can be added in any convenient form, including master alloy (for example an AI-10% Sr master alloy) or as strontium containing granules or powders. In some embodiments, it may be advisable to use an AA1xxx alloy containing strontium in the aluminum alloy. In alternative or complementary embodiments, it can be contemplated to add a strontium as an aluminum alloy such as, for example, wrought alloys (including AA2xxx, AA3xxx, AA4xxx or AA6xxx), or casting alloys (including AA2xx or AA3xx).

In some embodiments, the additive capable of causing the formation of a peritectic reaction's product can be scandium and the aluminum alloy can comprises or contains scandium in combination with titanium. In a composite material comprising between 4% and 40% (v/v) of B_4C particles, scandium can be provided at a concentration of between about 0.47 to about 3.75, between about 0.90 to about 3.75, between about 1.00 to about 3.75 or between about 1.10 to about 3.75 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration between about 0.50 to about 4.00, between about 0.90 to about 4.00, between about 0.95 to about 4.00, between about 1.00 to about 4.00 or between about 1.10 to about 4.00 with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 4.5% and 18.9% (v/v) of B_4C particles, scandium can be provided at a concentration of between about 0.38 to about 1.88, between about 0.90 to about 1.88, between about 1.00 to about 1.88 or between about 1.10 to about 1.88 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration of between about 0.40 to about 2.00, between about 0.90 to about 2.00, between about 0.95 to about 2.00, between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect to the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 19% and 28% (v/v) of B_4C particles, scandium can be provided at a concentration of between about 1.69 to about 2.82 weight percentage with respect to the composite material (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration between about 1.80 to about 3.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. In a composite material comprising between 25% and 28% (v/v) or 28% and 33% of B_4C particles, scandium can be provided at a concentration of between about 0.94 to about 1.88, between about 1.00 to about 1.88 or between about 1.10 to about 3.88 weight percentage with respect to the composite material (comprising the B_4C particles) total weight, whereas titanium can be provided at a concentration between about 1.00 to about 2.00 or between about 1.10 to about 2.00 weight percentage with respect of the composite material's (comprising the B_4C particles) total weight. It will be understood that the scandium concentrations given in the foregoing description, whether with reference to the aluminum alloy or the total composite material, represent scandium in all forms (including soluble Sc, excess Sc coming out of solution as intermetallics or refractory compounds, as well Sc-B compounds). The scandium can be added in any convenient form, including master alloy (for example an AI-10% Sc master alloy) or as scandium containing granules or powders. In some embodiments, it may be advisable to use an AA1xxx alloy containing scandium in the aluminum alloy. In alternative or complementary embodiments, it can be contemplated to add a scandium as an aluminum alloy such as, for example, wrought alloys (including AA2xxx, AA3xxx, AA4xxx or AA6xxx), or casting alloys (including AA2xx or AA3xx).

Without wishing to be bound to theory, the additive can be used in the methods described herein to form reaction products with B having an enthalpy of formation which is more negative than the one associated to AIB_2. For example, when vanadium is used in an aluminum alloy comprising titanium, it is believed, without being bound by theory, that this addition would force another reaction with titanium. The reaction product could be a compound such as $(Ti,V)B_2$. The formation of such reaction products would stop or reduce the reaction between the aluminum melt containing titanium and the B_4C particles. The present disclosure thus provides for the addition of additive capable of causing the formation of a peritectic reaction's products as inhibitors of the reaction between the aluminum melt and the B_4C particles to maintain the fluidity of the composite until the composite is shaped, preferably cast.

Theoretical calculations of the enthalpy of formation of reaction products expected to form after the addition of various elements were carried out using the software FactStage™ and are shown in Table 1.

Table 1. Theoretical values of enthalpy of formation of various reaction products.

Element added	Peritectic reaction product with B_4C	Enthalpy of formation (kJ/mol)
	AlB_2	**-67**
Cr	CrB_2	-94
Mo	MoB_2	-150
V	VB_2	-202
Ta	TaB_2	-222
Nb	NbB_2	-251
Ti	TiB_2	-280
Hf	HfB_2	-320
Zr	ZrB_2	-326
W	W_2B_9	-375

In an embodiment, the additive includes, but is not limited to chromium (Cr), molybdenum (Mo), vanadium (V), niobium (Nb), hafnium (Hf), zirconium (Zr), strontium (Sr), scandium (Sc), tantalum (Ta), tungsten (W) as well as any combination thereof. In another embodiment, the additive includes, but is not limited to (Mo), vanadium (V), niobium (Nb), hafnium (Hf), zirconium (Zr), strontium (Sr), scandium (Sc) as well as any combination thereof. In still another embodiment, the additive includes, but is not limited to zirconium (Zr), strontium (Sr), scandium (Sc) as well as any combination thereof. In yet a further embodiment, the additive comprises or consists of Cr. In yet another embodiment, the additive comprises or consists of Mo. In still a further embodiment, the additive comprises or consists of V. In yet another embodiment, the additive comprises or consists of Nb. In another embodiment, the additive comprises or consists of Ta. In yet another embodiment, the additive comprises or consists of W. In still a further embodiment, the additive comprises or consists of Hf. In another embodiment, the additive comprises or consists of Zr. In yet a further embodiment, the additive comprises or consists of Sr. In still a further embodiment, the additive comprises or consists of Sc. In one embodiment, the additive comprises or consists of a combination of Zr and Sc. In another embodiment, the additive comprises or consists of a combination of Zr and Sr. In yet another embodiment, the additive comprises or consists of a combination of Sr and Sc. In yet another embodiment, the additive comprises or consists of a combination of Zr, Sr and Sc.

To provide the molten aluminum alloy, the additive(s), an optionally titanium, is (are) added to molten aluminum or to a molten aluminum or a molten aluminum alloy. In some embodiments, it is contemplated to mix/stir the elements of the molten aluminum alloy to obtain a substantially homogenous molten aluminum alloy. In alternative or complementary embodiments, it is contemplated to apply heat to the molten aluminum alloy to obtain a substantially homogenous molten aluminum alloy.

ln some embodiments and as indicated above, an aluminum alloy containing titanium can be used. In such embodiment, it is not necessary to add the titanium and the additive (or a combination of additives) in a specific order to the aluminum or aluminum alloy. In an embodiment, the titanium is first added to the molten aluminum/alloy and then the additive(s) is (are) added. In an alternative embodiment, the additive(s) is (are) first added to the molten aluminum/alloy and then the titanium is added. In still another embodiment, the titanium and the additive(s) are added simultaneously to the molten aluminum/alloy.

Once the molten aluminum alloy is provided, it is combined with a source of boron carbide (a boron carbide powder (such as a free-flowing powder) for example) to provide a molten composite material comprising dispersed boron carbide particles. In the molten composite material, it is understood that the aluminum alloy (supplemented with the additive and optionally titanium) is in a molten form and that the boron carbide particles are in a solid form and are at least partially in association with the products of the peritectic reaction. In some embodiments, it may be advisable to add the source of boron carbide (e.g. , the boron carbide powder) to the molten aluminum alloy described herein. In some embodiments, it is contemplated to mix/stir the elements of the molten composite material to obtain a substantially homogenous molten composite material having dispersed B_4C-containing particles. The term "dispersed" means that the B_4C-

containing particles are distributed substantially uniformly throughout the material's matrix. In some embodiments, it is contemplated that the mixing/stirring be carried out in a manner that allows the appropriate wetting of the B_4C particles in the composite material.

The molten composite material, due to the presence of the products of the peritectic reaction products, has a fluidity amenable for casting in an industrial setting. Fluidity can be determined by various ways as known by those skilled in the art. In one example, fluidity is measured with a viscometer. In another example, fluidity is assessed by measuring the length of a cast sample in a mold. In order to do so, it is possible to add a quantity of B_4C powder inside a reactor (capacity of about 35 kg for example) that contains liquid aluminum-based mixture at a specific temperature (about 700°C for example) to which a vacuum is applied. Samples of the mixture of molten metal and B_4C powder can be obtained at a fixed interval (for example, every 20 minutes) using a step-mold and having a predetermined length. In some embodiments, a K-mold step-mold can be used. Fluidity is quantified as the distance achieved/covered by the resulting mixture before its solidification. In some embodiments, the K-mold can be a graphite-coated stainless steel step-mould having a sample-receiving chamber or groove having a width of 33 mm (and, in some embodiments, a maximal length of 315 mm) and being inclined at an angle of about 10°. For example, a molten composite material achieving a distance of 100 mm after 120 minutes of holding time in the K-mold described above is considered as having a fair fluidity for direct chilled casting. In another example, a molten composite material achieving a distance of 190 mm after 120 minutes of holding time in the K-mold described above is considered as having an excellent fluidity for direct chilled casting. In an embodiment, the fluidity of the composite material is 190 mm or more after 120 min. In yet further embodiments, the fluidity of the composite material is of 200 mm or more after 120 minutes. In an embodiment, the fluidity of the molten composite is at least 100 mm when measured at a temperature of about 700°C after a holding time of 120 min. In embodiment, the fluidity of the composite material is at least 105 mm, 110 mm, 115 mm, 120 mm, 125 mm, 130 mm, 135 mm, 140 mm, 145 mm, 150 mm, 155 mm, 160 mm, 165 mm, 170 mm, 175 mm, 180 mm, 181 mm, 182 mm, 183 mm, 184 mm, 185 mm, 186 mm, 187 mm, 188 mm, 189 mm, 190 mm, 191 mm, 192 mm, 193 mm, 194 mm, 195 mm, 196 mm, 197 mm, 198 mm, 199 mm or 200 mm when measured at a temperature of about 700°C after a holding time of 120 min. In some embodiments, it is expected that the fluidity of the molten composite can vary upon holding time and holding temperature. In other embodiments, the fluidity of the composite material is not measured upon the mixture of the aluminum alloy and the boron carbide particles, but after the peritectic reaction products have been formed or even molten composite material is held at a specific temperature (e.g. , holding temperature) and for a specific amount of time (e.g., holding time).

In embodiments, it is contemplated to hold a sample of the composite material at a specific temperature for allowing the material to remain in a molten state. In specific embodiments, the composite material is held at a minimal holding temperature of equal to or higher than about 660°C, 670°C, 680°C, 690°C, 700°C, 710°C, 720°C, 730°C, 740°C, 750°C, 760°C, 770°C, 780°C, 790°C or 800°C. In specific embodiments, the composite material is held at a maximal holding temperature equal to or lower than about 800°C, 790°C, 780°C, 770°C, 760°C, 750°C, 740°C, 730°C, 720°C, 710°C, 700°C, 690°C, 680°C, 670°C or 660°C. In alternative embodiments, the composite material is held at a temperature ranging between the minimal holding temperature as defined above and the maximal holding temperature as defined above.

In some embodiments, it is contemplated to hold a sample of the composite material in a molten state for a specific holding time. In specific embodiments, the composite material is held for a minimal holding time of equal to or higher than about 20 min, 30 min, 40 min, 50 min, 60 min, 70 min, 80 min, 90 min, 100 min, 110 min, 120 min, 130 min, 140 min, 150 min, 160 min, 170 min, 180 min, 190 min or 200 min. In specific embodiments, the composite material is held for a maximal holding time equal to or lower than about 200 min, 190 min, 180 min, 170 min, 160 min, 150 min, 140 min, 130 min, 120 min, 110 min, 100 min, 90 min, 80 min, 70 min, 60 min, 50 min, 40 min 30 min or 20 min. In alternative embodiments, the specific holding time ranges between the minimal holding time as defined above and the maximal holding time as defined above.

In some embodiments, it is contemplated to cast the composite material during a specific casting time. In specific embodiments, the composite material is casted for a minimal casting time of equal to or higher than about 20 min, 30 min, 40, min, 50 min, 60 min, 70 min, 80 min, 90 min, 100 min, 110 min, 120 min, 130 min, 140 min, 150 min, 160 min, 170 min, 180 min, 190 min or 200 min. In specific embodiments, the composite material is casted for a maximal casting time equal to or lower than about 200 min, 190 min, 180 min, 170 min, 160 min, 150 min, 140 min, 130 min, 120 min, 110 min, 100 min, 90 min, 80 min, 70 min, 60 min, 50 min, 40 min 30 min or 20 min. In alternative embodiments, the specific casting time ranges between the minimal casting time as defined above and the maximal casting time as defined above.

The molten composite is amenable any form of casting (including DC casting of billets or slabs), casting of ingots for future remelting and casting as well as casting into shapes using any convenient form of shape casting. The cast composite can be further processed and is well adapted for further operations such as (a) remelting and casting a shape, (b) extrusion and (c) rolling or (d) forging.

The method described herein may be used for the preparation of any shaped aluminum boron carbide composite material, particularly those containing high levels of B_4C. Advantageously, in some embodiments, in the presence of additive, a lower-grade B_4C powder can be used without altering significantly the fluidity of the molten AI-Ti-B_4C composite.

The present invention will be more readily understood by referring to the following examples which are given to illustrate the invention rather than to limit its scope.

EXAMPLE I

A primary aluminum metal alloy (AA1100) was melted in a reactor at a temperature of 765°C. Ti was added and then Sr was added. Thereafter, B_4C particles were injected into the melt. The final concentrations of Ti and Sr were both 1.65 wt%. The final concentration of the B_4C particles was 28 vol %.

The final mixture was held at a temperature of about 700°C and two fluidity samples were obtained every 20 minutes. The fluidity measurements are shown in Table 2.

Table 2. Fluidity measurements resulting from Example I.

Time (min)	Fluidity Measurement #1 (mm)	Fluidity Measurement #2 (mm)
5	161	170
20	179	172
47	185	194
65	199	193
80	186	180
100	180	186
120	**205**	**191**

The results shown in Table 2 indicate that after a holding time of 120 minutes, the fluidity is higher than 190 mm, thereby allowing industrial casting of the composite material.

EXAMPLE II

A primary aluminum metal alloy (AA1100) was melted in a reactor at a temperature of 765°C. Zr was added. Thereafter, B_4C particles were injected into the melt. The final concentration of Zr was 3.8 wt%. The final concentration of the B_4C particles was 19 vol %.

The final mixture was held at a temperature of about 700°C and two fluidity samples were obtained at various intervals. Resulting fluidity measurements are shown in Table 3.

Table 3. Fluidity measurements resulting from Example II.

Time (min)	**Fluidity measurement (mm)**
10	260
20	280
40	295
60	306
80	291
100	200
120	**210**

The results shown in Table 3 indicate that after a holding time of 120 minutes, the fluidity is higher 190 mm, thereby allowing industrial casting of the composite material.

While the invention has been described in connection with specific embodiments thereof, it will be understood that the scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

WHAT IS CLAIMED IS:

1. A cast composite material comprising (i) aluminum, (ii) products of a peritectic reaction between an additive and boron, (iii) dispersed boron carbide particles, wherein:

- the additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium and any combination thereof; and
- a sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°.

2. The cast composite material of claim 1, wherein the cast length is at least 190 mm.

3. The cast composite material of claim 1 or 2, wherein the cast composite material is submitted to holding during a holding time and to casting during a casting time and wherein the combination of the holding time and the casting time is at least 120 minutes.

4. The cast composite material of any one of claims 1 to 3, wherein the additive is selected from the group consisting of zirconium, strontium, scandium and any combination thereof.

5. The cast composite material of any one of claims 1 to 3, wherein the additive is scandium.

6. The cast composite material of any one of claims 1 to 3, wherein the additive is strontium.

7. The cast composite material of any one of claims 1 to 3, wherein the additive is zirconium.

8. The cast composition material of any one of claim 1 to 7 further comprising titanium.

9. The cast composite material of any one of claims 1 to 8, wherein the concentration (v/v) of the dispersed boron carbide particles is between 4% and 40% with respect to the total volume of the cast composite material.

10. The cast composite material of claim 9, wherein the concentration (w/w) of the additive is between 0.47% and 8.00% with respect to the total weight of the cast composite material.

11. The cast composite material of claim 10, further comprising titanium at a concentration (w/w) between 0.50% and 4.00% with respect to the total weight of the cast composite material.

12. The cast composite material of any one of claims 1 to 8, wherein the concentration (v/v) of the dispersed boron carbide particles is between 4.5% and 18.9% with respect to the total volume of the cast composite material.

13. The cast composite material of claim 12, wherein the concentration (w/w) of the additive is between 0.38% and 4.00% with respect to the total weight of the cast composite material.

14. The cast composite material of claim 13, further comprising titanium at a concentration (w/w) between 0.40% and 2.00% with respect to the total weight of the cast composite material.

15. The cast composite material of any one of claims 1 to 8, wherein the concentration (v/v) of the dispersed boron carbide particles is between 19.0% and 28.0% with respect to the total volume of the cast composite material.

16. The cast composite material of claim 15, wherein the concentration (w/w) of the additive is between 1.69% and 6.00% with respect to the total weight of the cast composite material.

17. The cast composite material of claim 8, wherein the titanium is at a concentration (w/w) between 1.80% and 3.00% with respect to the total weight of the cast composite material.

18. The cast composite material of any one of claims 1 to 8, wherein the concentration (v/v) of the dispersed boron carbide particles is between 25.0% and 28.0% with respect to the total volume of the cast composite material.

19 The cast composite material of any one of claims 1 to 8, wherein the concentration (v/v) of the dispersed boron carbide particles is between 28.0% and 33.0% with respect to the total volume of the cast composite material.

20. The cast composite material of claim 18 or 19, wherein the concentration (w/w) of the additive is between 0.94% and 4.00% with respect to the total weight of the cast composite material.

21. The cast composite material of claim 20, further comprising titanium at a concentration (w/w) between 1.00% and 2.00% with respect to the total weight of the cast composite material.

22. A method of preparing a cast composite material, said method comprising:

(a) combining (i) a molten aluminum alloy comprising an additive capable of undergoing a peritectic reaction with boron with (ii) a source of boron carbide particles so as to provide a molten composite material comprising products of the peritectic reaction between the additive and boron and dispersed boron carbide particles, wherein:

- the additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof; and

- a sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°; and

(b) casting the molten composite so as to form the cast composite material.

23. The method of claim 22, wherein the cast length is at least 190 mm.

24. The method of claim 22 or 23, further comprising, prior to step (b), holding the molten composite material during a holding time and casting the molten composite during a casting time, wherein the combination of the holding time and the casting time is at least 120 minutes.

25. The method of any one of claims 22 to 24, further comprising, prior to step (a), providing the molten aluminum alloy by combining a molten aluminum or a molten aluminum alloy with the additive.

26. The method of any one of claims 22 to 25, wherein the additive is selected from the group consisting of zirconium, strontium, scandium and any combination thereof.

27. The method of any one of claims 22 to 25, wherein the additive is scandium.

28. The method of any one of claims 22 to 25, wherein the additive is strontium.

29. The method of any one of claims 22 to 25, wherein the additive is zirconium.

30. The method of any one of claims 22 to 29, wherein the molten aluminum alloy further comprises titanium.

31. The method of any one of claims 22 to 30, wherein the concentration (v/v) of the dispersed boron carbide particles is between 4% and 40% with respect to the total volume of the cast composite material.

32. The method of claim 31, wherein the concentration (w/w) of the additive is between 0.47% and 8.00% with respect to the total weight of the cast composite material.

33. The method of claim 32, further comprising titanium at a concentration (w/w) between 0.50% and 4.00% with respect to the total weight of the cast composite material.

34. The method of any one of claims 22 to 30, wherein the concentration (v/v) of the dispersed boron carbide particles is between 4.5% and 18.9% with respect to the total volume of the cast composite material.

35. The method of claim 34, wherein the concentration (w/w) of the additive is between 0.38% and 4.00% with respect to the total weight of the cast composite material.

36. The method of claim 30, wherein the titanium is at a concentration (w/w) between 0.40% and 2.00% with respect to the total weight of the cast composite material.

37. The method of any one of claims 22 to 30, wherein the concentration (v/v) of the dispersed boron carbide particles is between 19.0% and 28.0% with respect to the total volume of the cast composite material.

38. The method of claim 37, wherein the concentration (w/w) of the additive is between 1.68% and 6.00% with respect to the total weight of the cast composite material.

39. The method of claim 38, wherein the composite material further comprises titanium at a concentration (w/w) between 1 .80% and 3.00% with respect to the total weight of the cast composite material.

40. The method of any one of claims 22 to 30, wherein the concentration (v/v) of the dispersed boron carbide particles is between 25.0% and 28.0% with respect to the total volume of the cast composite material.

41. The method of any one of claims 22 to 30, wherein the concentration (v/v) of the dispersed boron carbide particles is between 28.0% and 33.0% with respect to the total volume of the cast composite material.

42. The method of claim 40 or 41, wherein the concentration (w/w) of the additive is between 0.94% and 4.00% with respect to the total weight of the cast composite material.

43. The method of claim 42, wherein the composite material further comprises titanium at a concentration (w/w) between 1 .00% and 2.00% with respect to the total weight of the cast composite material.

44. A cast composite material obtained by the method of any one of claims 22 to 43.

45. A method of improving the casting and/or shaping properties of a molten composite material comprising (i) aluminum, (ii) products of a peritectic reaction between an additive and boron, (iii) dispersed boron carbide particles, said method comprising combining (a) a molten aluminum alloy comprising the additive capable of undergoing the peritectic reaction with boron with (b) a source of boron carbide particles so as to provide a molten composite material, wherein:

- the additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof; and
- a sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°.

46. The method of claim 45, wherein the cast length is at least 190 mm.

47. The method of claim 45 or 46, wherein the molten composite further comprises titanium.

48. A method of facilitating shaping of a molten composite material comprising (i) aluminum, (ii) products of a peritectic reaction between an additive and boron, (iii)

dispersed boron carbide particles and, said method comprising combining (a) a molten aluminum alloy comprising the additive capable of undergoing the peritectic reaction with boron with (b) a source of boron carbide particles so as to provide a molten composite material, wherein:

- the additive is selected from the group consisting of chromium, molybdenum, vanadium, niobium, zirconium, strontium, scandium, and any combination thereof; and
- a sample of the composite material has a fluidity, after having been heated, prior to casting, to a temperature of about 700°C for about 120 minutes, corresponding to a cast length of at least 100 mm when measured using a mold having a groove for containing the sample, the groove having a width of about 33 mm, a height of between about 6.5 mm and about 4.0 mm and being downwardly inclined, from an horizontal axis, of about 10°.

49. The method of claim 48, wherein the cast length is at least 190 mm.

50. The method of claim 48 or 49, wherein the molten composite further comprises titanium.

51. The cast composite material of any one of claims 1 to 21 further comprising silicon at a concentration (w/w) between 0.12 and 1.0 % with respect to the total weight of the cast composte material.

52. The method of any one of claims 22 to 47, wherein the molten aliminium alloy further comprises silicon at a concentration (w/w) between 0.12 and 1.0 % with respect to the total weight of the cast composte material.

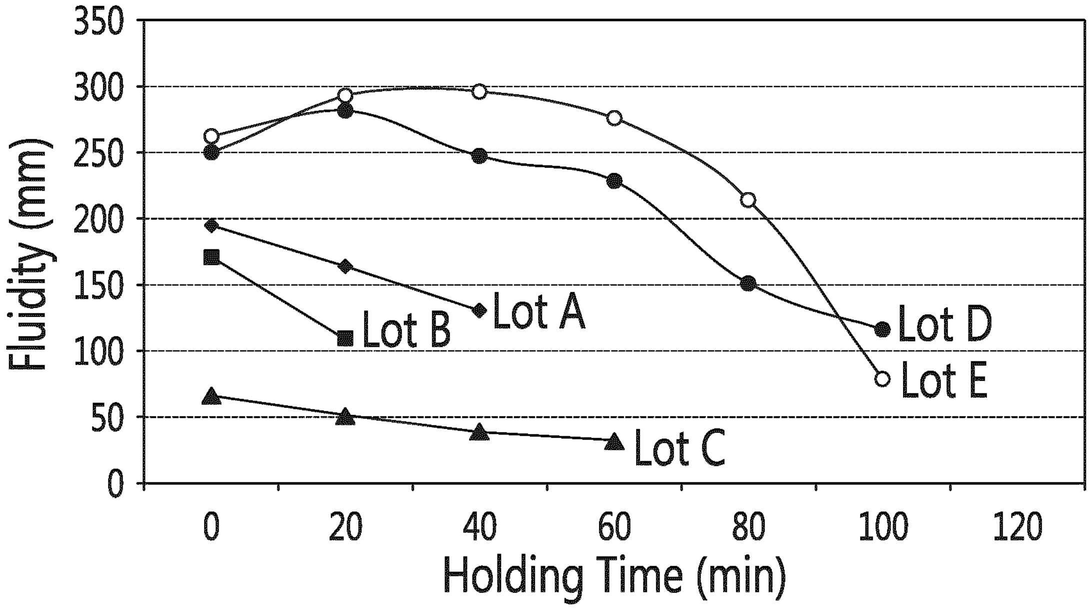
Fluidity (mm)
350
300
250
200
150
100
50
0
Holding Time (min)
0
20
40
60
80
100
120
Lot A
Lot B
Lot C
Lot D
Lot E

FIG. 1

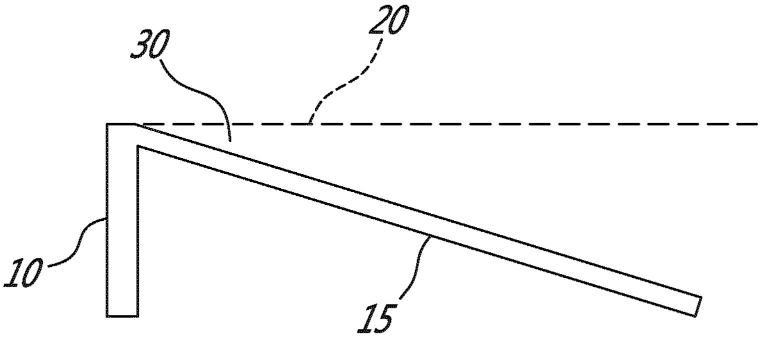

FIG. 2A

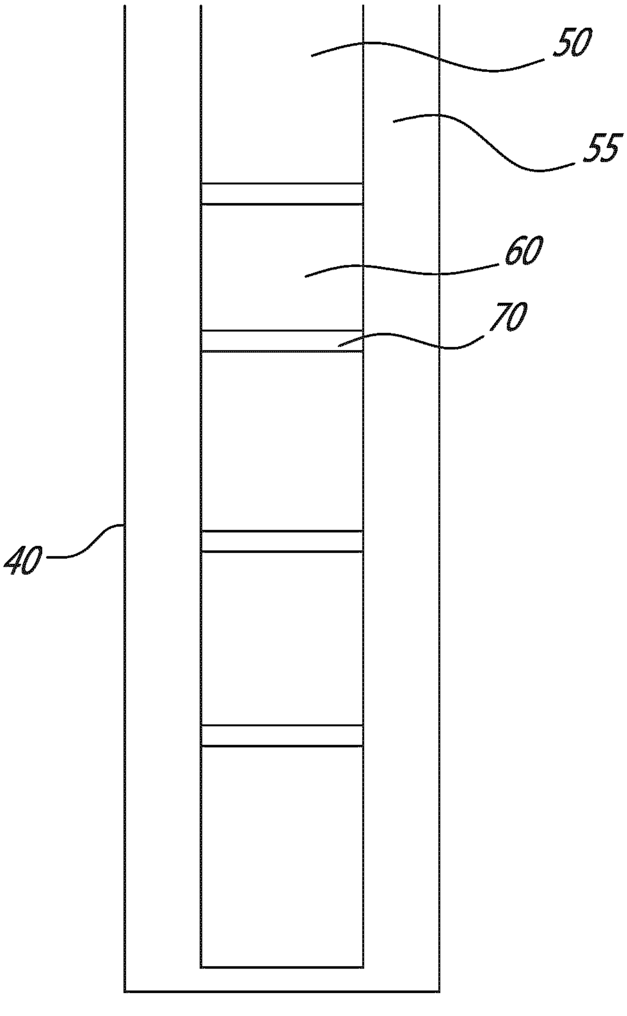

FIG. 2B

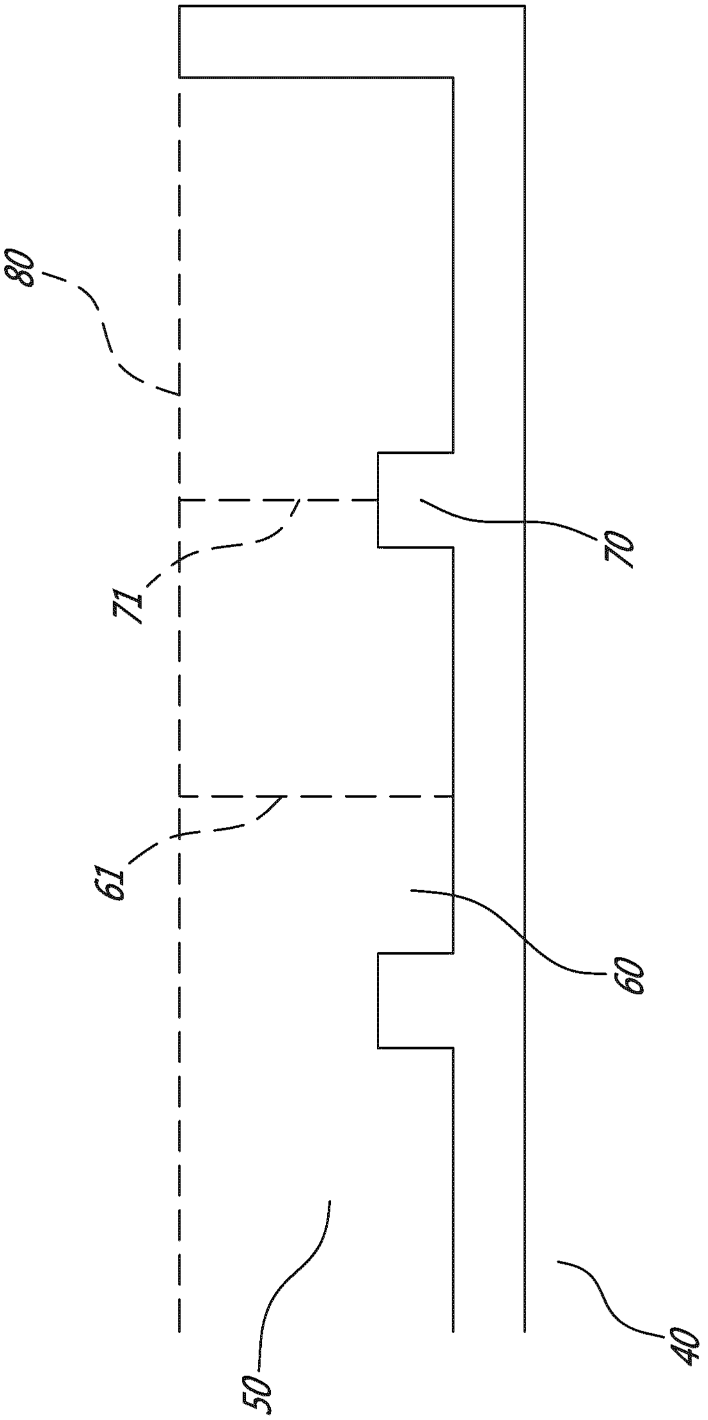

FIG-3