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3,379,522

**DISPERSOID TITANIUM AND TITANIUM-BASE ALLOYS**

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 7 Claims. (Cl. 75-201)

**ABSTRACT OF THE DISCLOSURE**

Production of titanium and titanium-base alloys embodying a submicron dispersion of a dispersoid selected from the group consisting of boron, cerium, sulphur and thorium and combinations and compounds thereof.

This invention pertains to titanium and titanium-base alloys containing submicron dispersions of particles essentially insoluble in solid titanium at any temperature, and to methods of producing such dispersoid alloys. More particularly the invention pertains to titanium-base alloys containing submicron-sized dispersions of one or more dispersoids selected from the group consisting of boron, cerium, thorium and sulphur and combinations and compounds thereof, such as Ti-B, Ce-S, and to methods of producing the same consisting of melting the components to form a homogeneous liquid, extreme chill-casting the liquid as by splashing it in thin layers against a cold solid surface or by spraying the liquid into a cold chamber wherein it freezes as fine shot, and finally consolidating the shot and splashings by pressure, heat and plastic deformation to a product of essentially theoretically full density.

In the extreme chill-casting described, the dispersoid particle components, although soluble in the liquid titanium, are insoluble in solid titanium and are thus forced by freezing of the liquid to separate as particles of extreme fineness because of the very short time available for growth. Thus the dispersoid particles appear as submicron-sized dispersions within the shot or splashed flakes which, although fine themselves relative to any standard ingots, are very coarse relative to the dispersoid particles. That is, the shot or flakes may be from perhaps 50 or 100 microns to several hundred microns in mean section, and the dispersed particles therein will be on the order of less than 1 micron.

The advantages of fine particle dispersions in alloys for elevated temperature use are well known, as are several methods for producing them. Most commonly, dispersions of particles in a base metal are formed as precipitates therein by suitable heat treatment of alloys containing components which are soluble in the solid alloy at high temperatures and less soluble at low. Such systems are very numerous and of great usefulness. Since the precipitate components are soluble at high temperatures, however, they tend to be of limited elevated temperature usefulness generally, and for use beyond their temperature range, dispersoids insoluble in the solid matrix are desired.

Alloys containing insoluble, stable and inert particle dispersions, and methods of making them are also well known. The most used conventional method consists of mixing extremely fine powders of basis metal and of dispersoids, compacting, sintering and working the mixtures to solidify them. In the case of titanium, the high reactivity of submicron powders thereof and the ready solubility of contaminants, as for example from air, make the powder approach impractical. Shot and flake as described herein have several hundred times less surface

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per unit mass than conventional powders, and handling is therefore not difficult. The submicron particles exist in the shot and flake as made according to the invention, and submicron titanium powder is unnecessary.

Another well known method of making stable dispersoid systems consists of internal oxidation of solid solutions of active metals in a less reactive base metal, such for example as titanium containing in solid solution, certain rare earth metals which can be oxidized in situ to form stable particles of oxide. The combined requirements of solid solubility of the metallic component of the dispersoid, plus greater reactivity than titanium, essentially limits the possibilities for this approach to the rare earths. Also, the rare earth oxides are stable only in titanium which of itself contains a substantial oxygen content, which is usually undesirable.

The dispersoids above-mentioned with reference to this invention, are all insoluble in solid titanium, and when present as submicron dispersions as produced in accordance with the methods of the invention, impart outstanding elevated temperature creep properties operable to higher temperature levels than is attainable with dispersoid type titanium and titanium-base alloy materials heretofore available insofar as I am aware.

**EXAMPLE**

In practice of the invention, liquid titanium alloys containing up to 2% B or up to 6% Th or up to 3% Ce, 1% S or in combinations thereof up to enough to form a maximum of about 5 v/o of particles, are shot as described for example in U.S. Patent No. 2,897,539. The shot are then consolidated by known methods such as canning and hot pressing. Mill products are made from the hot pressed billets by conventional means.

Maximum usefulness of inert dispersoid-containing alloys as described herein occurs under conditions of very long time and/or high temperature exposure.

The following Table I shows for a Ti-6Al-2Sn-4Zr-2Mo alloy, creep strength with long-term aging without and with an inert submicron dispersoid according to the invention.

TABLE I.—Creep deformation of cast alloys aged 200 hours at 1100° F. and stressed to 30K s.i. at 1000° F. for 150 hours

Alloy:	Deformation, percent
Ti-6Al-2Sn-4Zr-2Mo	0.421
Ti-6Al-2Sn-4Zr-2Mo-1.7Ce-0.5S	0.167

Inclusion of the dispersoid thus reduces the creep deformation approximately 60% in this alloy.

The effects of dispersoid particle size variation in titanium and titanium-base alloys are shown by the following comparative tests. In Table II below a dispersoid was produced in a very coarse-grained condition in the two titanium-base alloys shown, and the creep deformation measured for the alloy without and with the dispersoid.

TABLE II

Alloy:	Deformation, 1000° F.-30K s.i.-150 hr.
Ti-8Al	0.06
Ti-8Al and dispersoid	0.20
Ti-8Al-1Mo-1V	0.26
Ti-8Al-1Mo-1V and dispersoid	0.50

It is thus shown that coarse grained dispersoids are damaging to creep.

In contrast in the following Table III, there is shown the effect of a fine dispersoid on the order of one micron in particle size.

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Table III

Alloy:	Deformation, 1000° F.-30K s.i.-150 hr.
Ti-Al .....	0.06
Ti-Al and dispersoid .....	0.005

Thus the presence of an inert dispersoid in particle size on the order of a micron greatly improves the creep properties.

I claim:

1. The method of producing in a base metal selected from the group consisting of titanium and titanium-base alloys, a submicron dispersion of a dispersoid selected from the group consisting of B, Ce, S and Th and combinations and compounds thereof, which comprises: melting said base metal and dispersoid together to produce a homogeneous molten liquid thereof, and chill-casting said molten liquid in a subdivided state to produce solid particles of said base metal containing said dispersoid as a submicron dispersion therein.

2. The method according to claim 1 wherein said molten liquid is chill-cast into relatively small solid particles by splashing in a thin stream against a cold solid surface.

3. The method according to claim 1 wherein said molten liquid is chill-cast into relatively small solid particles by spraying into a cold chamber.

4. The method according to claim 1 wherein said molten liquid is chill-cast into solid particles on the order of approximately 50 to several hundred microns in particle size.

5. The method according to claim 1 wherein said solid particles are consolidated by heat and pressure into a shaped article.

6. The method according to claim 5 wherein said shaped article is subjected to plastic deformation further to consolidate said solid particles.

7. The method according to claim 5 wherein said shaped article is subjected to hot plastic deformation further to consolidate said solid particles.

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