PRODUCTION OF AGE HARDENABLE TANTALUM-BASED ALLOYS

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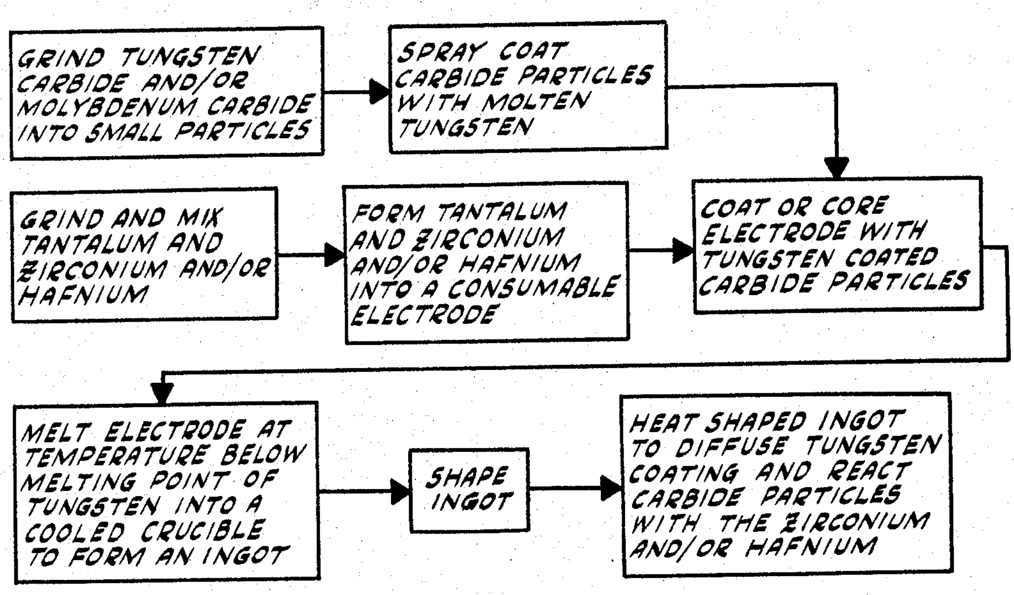

FIG-1

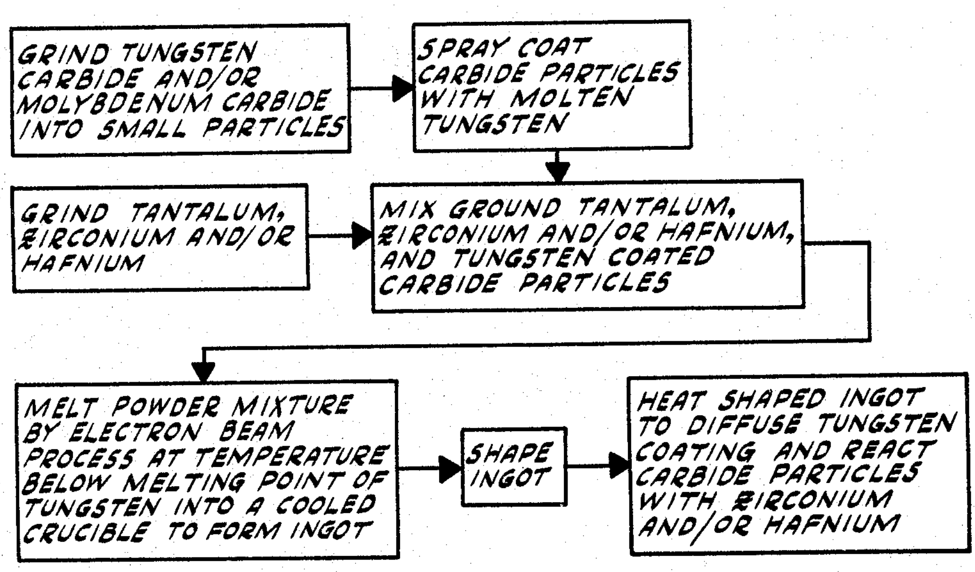

FIG-2

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PRODUCTION OF AGE HARDENABLE TANTALUM-BASED ALLOYS

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This invention relates to tantalum-based alloys, and more specifically to a manner of improving the properties of such alloys by dispersion hardening.

It is known that the physical properties of tantalum can be greatly improved by alloying tantalum with molybdenum and/or tungsten to form various solid solution alloys. Further improvements can be obtained by minor additions of rhenium and/or ruthenium.

It is also known that the physical properties of the best single-phase (solid solution) tantalum alloys can be further improved by dispersion hardening. In this latter process small additions of zirconium and/or hafnium and carbon are dispersed uniformly through an ingot of tantalum. The zirconium and/or hafnium reacts with the carbon to form a fine carbide dispersion to produce a two-phase alloy having a greatly improved high temperature strength. Such alloys, however, are of limited use since fabrication of the alloys into sheet form or other shapes is extremely difficult by conventional processes.

The object of this invention is to produce tantalum alloys which can be fabricated as readily as relatively low alloy tantalum materials and which may, after fabrication, be treated to develop the maximum in high-temperature physical properties obtainable by dispersion hardening.

In general, the object of this invention is carried out by forming ingots of tantalum alloy with zirconium and/or hafnium dispersed therein and with carbon dispersed therein, the carbon being dispersed in such manner that initially it is not free to react with the zirconium and/or hafnium. After fabrication of the ingot into the desired shape, the carbon is released for reaction with the zirconium and/or hafnium to form a fine carbide dispersion in the tantalum alloy.

In the drawings forming a part of this application,

FIG. 1 is a flow chart setting forth the procedure involved in carrying out the invention, utilizing a consumable electrode process in the ingot formation.

FIG. 2 is a flow chart setting forth the procedure involved in carrying out the invention, utilizing an electron beam process in the ingot formation.

More specifically, the invention is carried out as follows: An ingot of tantalum-based alloy is formed, or grown, by conventional consumable electrode or electron beam processes.

In the consumable electrode process set forth in FIG. 1 tantalum is ground into powder and is mixed with small quantities of zirconium and/or hafnium powder. If desired, small quantities of powdered tungsten, molybdenum, rhenium and/or ruthenium are added. The powder mix is then pressed into an electrode of preferably about 80% density.

The electrode is then coated with metal-coated carbide particles. The carbide particles are preferably molybdenum carbide and/or tungsten carbide, having a size of 30–100 microns, which particles are coated with tungsten, a metal having a higher melting point than tantalum. The coated carbide particles may be formed by conventional grinding of the molybdenum carbide or tungsten carbide to the desired size and by then coating them by conventional metal spraying techniques wherein the carbide particles are blown through a spray of molten tungsten.

Alternatively, instead of coating the electrode with the tungsten-coated carbide particles, the electrode may be cored and filled with the tungsten-coated carbide particles.

The electrode is then melted at a temperature below the melting point of tungsten into a water-cooled crucible so that a solid ingot is grown therein. As the ingot is formed, the zirconium and/or hafnium and the metal-covered carbide particles are finely and uniformly dispersed throughout the ingot. Since the tungsten coatings of the carbide particles have a higher melting point than tantalum, the coatings do not melt as the ingot is formed and the carbide particles trapped therein are prevented from reacting with the zirconium and/or hafnium during that time.

If the electron beam process of FIG. 2 is used, tantalum, zirconium and/or hafnium, and tungsten, molybdenum, rhenium and/or ruthenium, and the tungsten-covered carbide particles are mixed, following conventional powder metallurgy techniques, and melted at a temperature below the melting point of tungsten into a cooled crucible by electron beam melting to form an ingot in which the zirconium and/or hafnium and the tungsten-coated carbide particles are finely dispersed throughout.

The ingot is cooled and fabricated to sheet or other shapes as desired by techniques usable for non-dispersion-hardened tantalum alloys. Preferably such fabricating is carried out at room temperature, or at temperatures considerably below the melting point of the coatings of the carbide particles in order to inhibit diffusion of the coatings into the tantalum alloy. In this manner, the carbide particles are thus not effective as dispersion hardening agents during fabrication of the ingot.

Following conversion of the ingot to its desired shape, the alloy is heated and held at a high temperature, which may be at about 90% of the melting point of tantalum. During this time the molybdenum or tungsten coatings on the carbide particles diffuse from the carbide particles into the alloy. The tungsten carbide particles decompose and the carbon thus made available reacts with the zirconium and/or hafnium present to produce a fine zirconium and/or hafnium carbide dispersion to effect the required dispersion hardening of the alloy.

Additionally, the tungsten produced by the carbide decomposition becomes available to increase the solid solution alloying and thus obtains an added increment in improvement in physical properties compared to those of the original ingot.

It is to be understood that the above described methods are the preferred manners of carrying out the invention, and that other equivalent steps may be used without departing from the spirit of the invention or the scope of the following claims.

Having thus described my invention, what I claim is:

1. The method of hardening tantaum-based alloys comprising the steps of:

dispersing tungsten-coated carbide particles uniformly in an ingot of tantalum-based alloy;

maintaining said alloy at an elevated temperature to diffuse the coatings from said carbide particles.

2. The method as set forth in claim **1** wherein said carbides are selected from the group consisting of tungsten carbide and molybdenum carbide.

3. The method of hardening tantalum-based alloys comprising the steps of:

dispersing metal-coated carbide particles uniformly in an ingot of tantalum alloyed with small quantities of metal selected from the group consisting of zirconium and hafnium;

maintaining the alloy at an elevated temperature to diffuse the coatings from said carbide particles.

4. The method as set forth in claim **3**, wherein said carbides are selected from the group consisting of tungsten carbide and molybdenum carbide, and wherein said carbide particles are coated with tungsten.

5. The method of working and hardening tantalum-based alloys, comprising the steps of:

melting tantalum and a small quantity of metal selected from the group consisting of zirconium and hafnium at a temperature lower than the melting point of tungsten, and forming an ingot thereof;
dispersing tungsten-coated carbide particles uniformly in said ingot as said ingot is formed;
cooling said ingot;
shaping said ingot;
heating and maintaining said shaped ingot at an elevated temperature to diffuse the coatings from said carbide particles.

6. The method as set forth in claim 5 wherein said carbides are selected from the group consisting of tungsten carbide and molybdenum carbide.

7. An alloy comprising tantalum having a small quantity of metal selected from the group consisting of zirconium and hafnium dispersed uniformly therethrough and having tungsten-coated carbide particles dispersed uniformly therethrough.

8. An alloy as set forth in claim 7 wherein said carbide particles are selected from the group consisting of tungsten carbide and molybdenum carbide.

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