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(54) **TUNGSTEN CARBIDE RING COMPOSITION**

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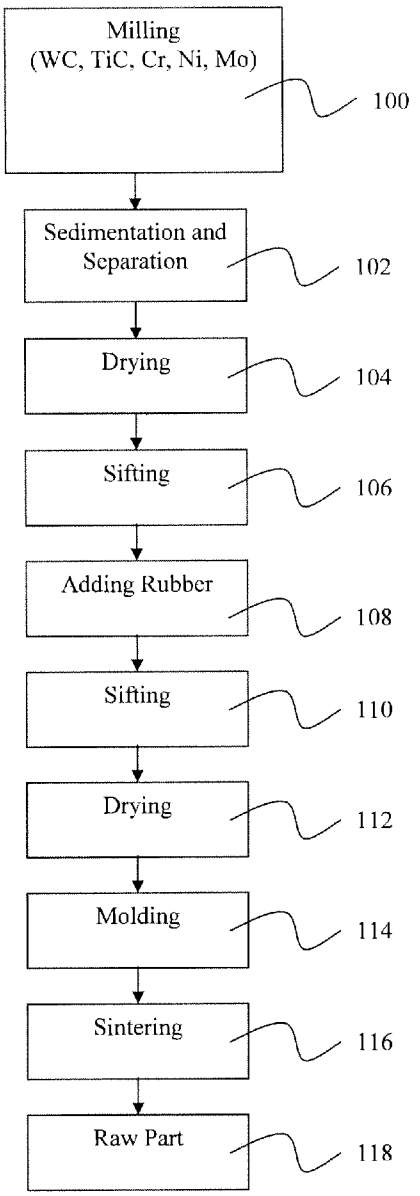
(57) **ABSTRACT**

A powder mixture composition for forming a jewelry article is described, comprising about 20-44% by weight tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum. Methods of forming a jewelry article also are described, as are formed jewelry articles.



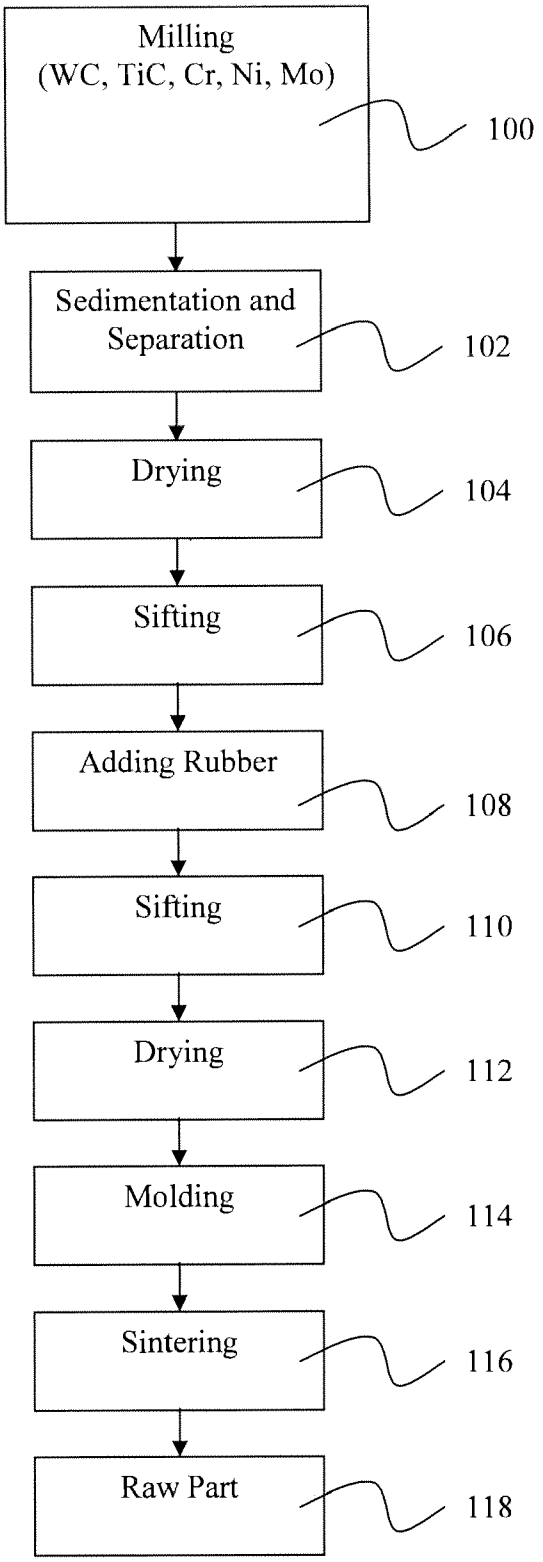
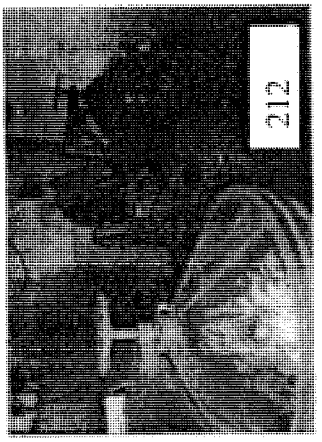
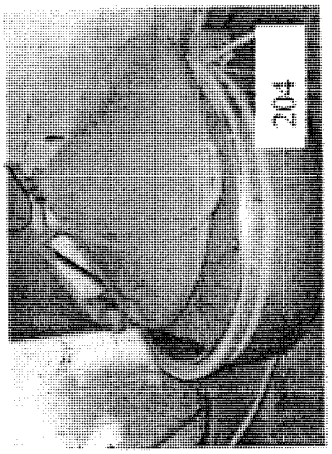

Milling
(WC, TiC, Cr, Ni, Mo)
100
Sedimentation and
Separation
102
Drying
104
Sifting
106
Adding Rubber
108
Sifting
110
Drying
112
Molding
114
Sintering
116
Raw Part
118

Fig. 1

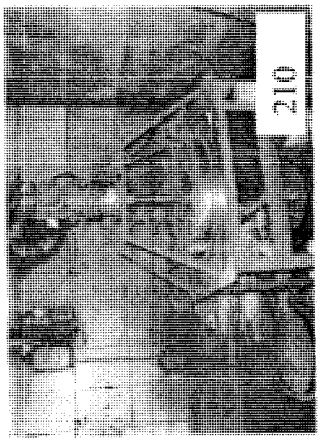
Drying



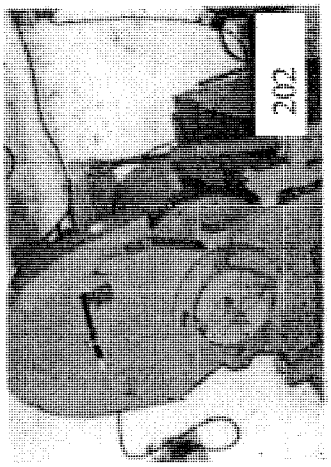
Drying



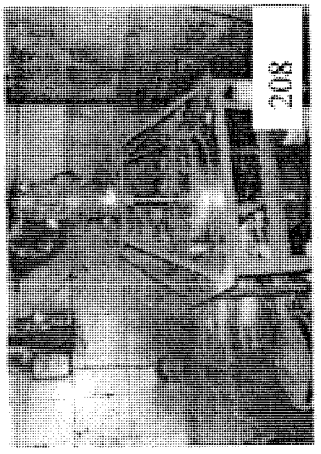
Sedimentation/Separation



Sifting and Adding rubber



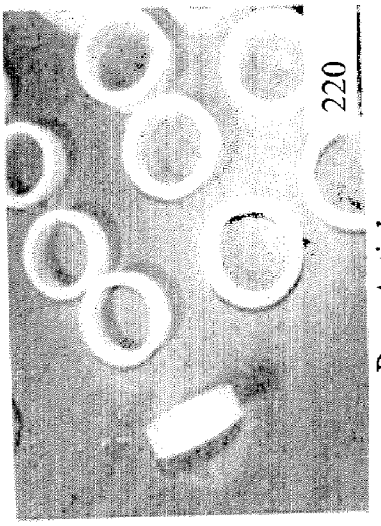
Milling



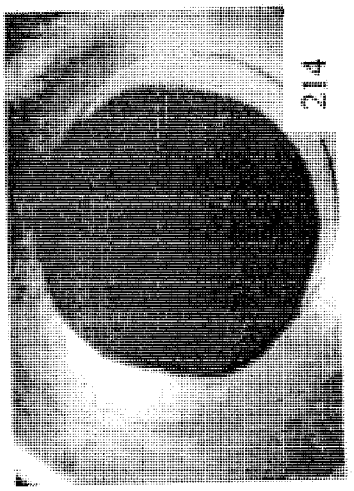
Adding rubber

Fig. 2A

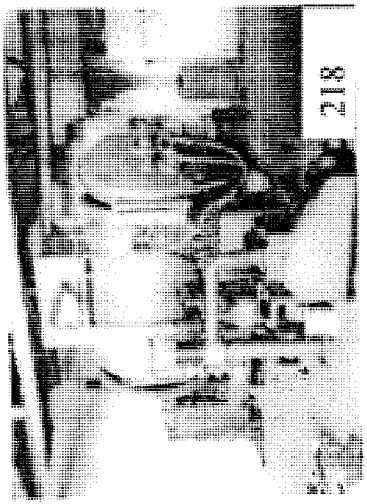
Molding



Raw Articles



Powder



Sintering

Fig. 2B

Elapsed Time, HR	0	1	3	5	7	9	10	11.5	12.0	12.5	13.5	14.0	15.5	16.5	17.3	31.3	
temperature C	30	350	350	550	550	650	650	900	1100	1100	1200	1200	1360	1400	1400	30	
Heating time		1		2		2		1.5	0.5		1		1.5	1			
Holding time			2		2		1			0.5		0.5			0.8		
Cooling time																14	

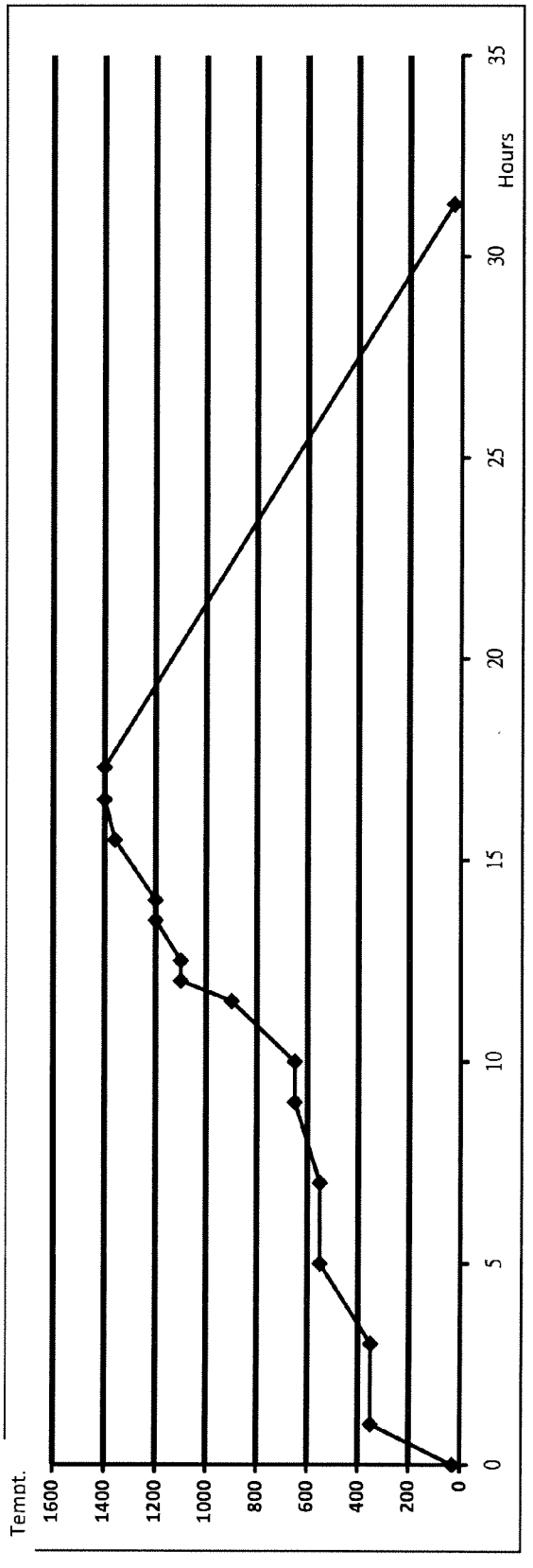


FIGURE 3

TUNGSTEN CARBIDE RING COMPOSITION

BACKGROUND

[0001] The present invention generally relates to the field of jewelry articles and specifically jewelry articles comprising tungsten carbide.

SUMMARY

[0002] In accordance with some embodiments, there is provided a powder mixture composition for forming a jewelry article, comprising about 20-44% by weight tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum. In specific embodiments, the powder mixture comprises about 35-44% by weight tungsten carbide; about 18-27% by weight titanium carbide; about 1-2% by weight chromium, about 17-21% by weight nickel, and about 5-7% by weight molybdenum.

[0003] In accordance with other embodiments, there is provided a method of forming a jewelry article comprising providing a powder mixture composition comprising about 20-44% by weight tungsten carbide and one or more of titanium carbide, chromium, nickel, and molybdenum; optionally, placing the powder mixture composition into a mold; and applying sufficient pressure and/or temperature to the powder mixture composition to form a solid jewelry article. In specific embodiments, the jewelry article is a ring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a flow diagram illustrating the steps in the manufacture of a jewelry article, in accordance with one embodiment.

[0005] FIGS. **2**A-**2**B are images of jewelry article manufacture equipment, a powder mixture and raw jewelry articles.

[0006] FIG. **3** illustrates a thermocycle for forming a jewelry article from a powder mixture composition as described herein.

DETAILED DESCRIPTION

[0007] The present invention provides powder mixture compositions for forming a jewelry article. The powder mixture composition comprises tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum. In specific embodiments, the powder mixture composition comprises about 20-44% by weight tungsten carbide. The powder mixture compositions described herein can be used to make jewelry articles with desirable (enhanced) durability properties.

[0008] The present invention also provides methods of forming jewelry articles, comprising (a) providing a powder mixture comprising tungsten carbide, and one or more metallic and/or ceramic component(s), (b) optionally, placing the powder mixture in a mold and (c) applying sufficient pressure and/or temperature to the powder mixture to form a solid jewelry article. Thus, the jewelry article formed according to the present embodiments comprises tungsten carbide, and one or more metallic and/or ceramic components.

[0009] As used herein, the term "about" will be readily understood by the skilled artisan based on the context and conventions in the art. For example, "about" may encompass values ±1% of the stated values. All percent ranges described herein are by weight and include every individual value within each range.

Powder Mixture

[0010] In one embodiment, the powder mixture comprises tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum. In specific embodiments, the powder mixture comprises tungsten carbide, titanium carbide, chromium, nickel, and molybdenum. For example, nickel can act as a binder.

[0011] The weight percentage range of each component in the mixture may vary depending on the desired physical properties and/or aesthetic appearance of, for example, a the jewelry article made therefrom.

[0012] In general, the weight percent of tungsten carbide in the powder mixture is about 20-44%. In some specific embodiments, the weight percent of tungsten carbide in the powder mixture is about 35-44%.

[0013] With regard to other components, the powder mixture may comprise, for example, one or more of: about 18-27% titanium carbide; about 1-2% chromium; about 17-21% nickel; and about 5-7% molybdenum.

[0014] In one specific illustrative embodiment, the powder mixture comprises about 44% by weight tungsten carbide; about 27% by weight titanium carbide; about 1% by weight chromium, about 21% by weight nickel, and about 7% by weight molybdenum.

[0015] The powder mixture composition can be prepared by any means. In one embodiment, the powder mixture is prepared by milling a particle mixture of the components (e.g., tungsten carbide and one or more of the other components mentioned above) for a sufficient period of time to reduce the size of the mixture particles. In another embodiment, the powder mixture is prepared by combining components that are already in powder form (e.g., as fine particles). In a further embodiment, in addition to milling, the mixture is also subject to one or more steps of sedimentation/separation, drying and sifting.

[0016] The particle size range in the powder mixture is advantageously small enough to allow effective sintering of said powder mixture. If needed, particle size may be reduced by running a particle mixture through a sieve, to obtain smaller particle sizes. For instance in a non-limiting example, a mixture is run through one or more sieves with mesh hole diameter(s) less than 0.40 mm to obtain a powder mixture with an average particle size of about 1-2 μm.

[0017] In a non-limiting example, a mixture comprising tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum is milled, followed by sedimentation/separation, drying and sifting steps to form a powder mixture.

[0018] In another non-limiting example, a mixture of tungsten carbide, and one or more of titanium carbide, chromium, nickel, and molybdenum is subjected to (a) milling, (b) sedimentation/separation, (c) drying, (d) sifting and again (e) drying to form a powder mixture.

[0019] In one embodiment, the powder mixture also comprises at least one rubber material. In one aspect, the rubber may assist in binding the powder particles together. In a further aspect, the rubber may assist in processing and shaping the powder mixture. Thus, the amount of rubber added may vary depending on the processing and shaping requirements. Examples of suitable rubbers include, but are not

limited to, latex rubbers, butadiene rubbers, styrene butadiene rubbers, thermoplastic elastomers and melt processible rubbers. Of course, a combination of different types of rubbers may also be used. In some embodiments, the rubber material comprises styrene-butadiene-styrene (SBS). However, other similar polymeric materials such as styrene-isoprene-styrene may be equally useful. Where the mixture processing step includes milling, the rubber material may advantageously be added after the milling step.

[0020] In one embodiment, the powder mixture also comprises components which impart color to a jewelry article made therefrom. For instance an amount of a nitride may be added to change the color of the article.

[0021] In certain cases, the weight percent of tungsten carbide and other components in the powder mixture may differ from that in a raw jewelry article made therefrom. For instance, addition of other components, such as SBS (styrene-butadiene-styrene) rubber or coloring agent, may lower the weight percent of the powder mixture components in the raw jewelry article. Still, in some embodiments, the weight percent of the components in the powder mixture and jewelry article maybe about the same, such as if no other components are used, or if only minor amounts of other components are used.

Forming A Jewelry Article

[0022] Once formed, the powder mixture composition may be formed into a jewelry article, such as by exposing the powder mixture composition to elevated temperatures and/or pressures to form a jewelry article. For example, the powder mixture composition may be placed in the cavity of a mold and subjected to elevated temperature (optionally under a vacuum) and/or pressure to form a raw jewelry article.

[0023] Any mold can be used. For example, the mold cavity may be shaped according to any basic jewelry article design. In specific embodiments, the mold cavity produces an annular shaped jewelry article, such as for a ring. The formed raw jewelry article may comprise one or more facets, grooves, or notches.

[0024] In a non-limiting example, the powder mixture is sintered in a mold at a temperature of about 1400-1450° C. In yet another non-limiting example, the powder mixture is first heated at about 550° C. before sintering, such as to remove the rubber contents (wax).

[0025] After molding, the raw jewelry article may be then subject to further processing steps, such as attaching precious metals pieces or gems to the article.

[0026] The flow diagram of FIG. **1** provides a non-limiting example of manufacturing steps **100-118**, for forming a jewelry article in accordance with one embodiment.

[0027] In step **100**, a mixture comprising, tungsten carbide (WC), titanium carbide (TiC), chromium (Cr), nickel (Ni), and molybdenum (Mo) is milled in ethanol for 72 hours. In step **102**, the milled mixture undergoes sedimentation/separation followed by a drying step **104** at 90-100° C., 1 atm for 2.5 hours. Following a sifting step **106**, an amount of SBS rubber is then added to the powder mixture in step **108**. This mixture is again sifted resulting in a powder mixture having particles sizes in the range of about 1-2 μm. The first and second sifting steps are carried out using a mesh with 0.19 mm and 0.38 mm diameter holes, respectively. The powder mixture is then dried in step **112** for about 1-1.5 hours and shaped in consecutive molding **114** and sintering **116** steps.

[0028] The sintering step is carried out in a vacuum furnace by first heating the raw article (to remove the rubber) at 550° C. for about 2 hours, then heating at 1400-1450° C. for about half an hour (such as 30-40 minutes), followed by cooling over a period of 10-14 hours to 30° C. or room temperature . The raw jewelry article is then obtained in step **118** for additional processing, as desired or required.

[0029] FIGS. **2**A-B depict manufacturing equipment connected with the steps shown in FIG. **1**. Specifically, FIG. **2**A shows a milling machine **202**, sedimentation/separation equipment **204**, drying equipment **206** and **212** and adding/sifting apparatus **208** and **210**. FIG. **2**B shows a molding unit **216**, a vacuum furnace **218**, a powder mixture **214** as well as raw jewelry articles **220**.

[0030] The manufacturing process described shows a 100 kg/day production capacity for powder mixture production. Also, the molding process has the capacity to handle 2500 pieces/mold in one day. Finally, the production of the raw jewelry article is about 5000 pcs/day.

[0031] FIG. **3** illustrates a non-limiting thermocycle for forming a jewelry article from a powder mixture composition as described herein. As shown, a powder mixture composition as described herein is placed in a mold in a vacuum furnace and the furnace temperature is raised slowly (e.g., over 16 hours) to a temperature of about 1400° C., including a holding period (e.g., about 2 hours) at 550° C. After a holding period (e.g., about 30-40 minutes) at 1400° C., the furnace temperature is slowly reduced (e.g., over 14 hours).

[0032] Although the foregoing refers to particular embodiments, it will be understood that the present invention is not so limited. It will occur to those of ordinary skill in the art that various modifications may be made to the disclosed embodiments and that such modifications are intended to be within the scope of the present invention.

What is claimed is:

1. A powder mixture composition for forming a jewelry article, comprising:

about 20-44% by weight tungsten carbide, and one or more of:

titanium carbide, chromium, nickel, and molybdenum.

2. The composition of claim **1**, wherein the powder mixture comprises about 35-44% by weight tungsten carbide.

3. The composition of claim **1**, wherein the powder mixture comprises about 18-27% by weight titanium carbide.

4. The composition of claim **1**, wherein the powder mixture comprises about 1-2% by weight chromium.

5. The composition of claim **1**, wherein the powder mixture comprises about 17-21% by weight nickel.

6. The composition of claim **1** wherein the powder mixture comprises about 5-7% by weight molybdenum.

7. The composition of claim **1**, comprising about 35-44% by weight tungsten carbide; about 18-27% by weight titanium carbide; about 1-2% by weight chromium, about 17-21% by weight nickel, and about 5-7% by weight molybdenum.

8. The composition of claim **1**, comprising about 44% by weight tungsten carbide; about 27% by weight titanium carbide; about 1% by weight chromium, about 21% by weight nickel, and about 7% by weight molybdenum.

9. The composition of claim **1**, further comprising a rubber material.

10. The composition of claim **1**, further comprising a rubber material comprising styrene-butadiene-styrene (SBS).

11. A method of forming a jewelry article comprising:

providing a powder mixture composition comprising about 20-44% by weight tungsten carbide and one or more of titanium carbide, chromium, nickel, and molybdenum;

optionally, placing the powder mixture composition into a mold; and

applying sufficient pressure and/or temperature to the powder mixture composition to form a solid jewelry article.

12. The method of claim **11**, wherein the mold comprises a cavity having an annular configuration.

13. The method of claim **11**, further comprising the step of adding a rubber material to the powder mixture composition.

14. A jewelry article formed according to the method of claim **11**.

* * * * *