Noble Metal Alloys

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ABSTRACT OF THE DISCLOSURE

Novel gold alloys having desirable properties of hardness and solidus temperatures are provided which comprise about 67.0 to 87.0 percent gold, about 7.0 to 15.0 percent palladium, about 2.0 to 10.0 percent platinum, and 0.5 to 1.0 percent of iron and about 0.5 to 2.0 percent tin, all based upon the total weight of the alloy. Optional alloying elements include up to about 2.0 percent silver, 1.5 percent zinc, 1.0 percent indium and 1.0 percent rhenium.

BACKGROUND OF THE INVENTION

Gold-base alloys containing platinum, palladium and the combination thereof are commonly employed for various applications in dentistry and in industry. In dentistry, such alloys find a large amount of use as base structures upon which porcelains are fired to provide tooth structures, crowns and the like. In industry, such alloys find widespread application in electronics applications because of their resistance to corrosion and desirable conductivity; for instance, ceramics are bonded thereto for insulating and other purposes.

Generally, the gold alloys intended for use in applications where porcelains or other ceramics are to be fired in contact therewith require high solidus temperatures. Many other alloys which have been developed for this purpose require constant-temperature age hardening or other highly critical hardening conditions in order to develop a reasonably high degree of hardness. In addition, when such alloys are used in the cast condition rather than in a wrought condition, variations in hardenability may be encountered with variations in casting temperature.

Typically, the gold-base alloys for ceramic applications will harden only to 15 kg. Brinell hardness levels on the order of 150 B.H.N. unless a constant-temperature age hardening heat treatment is employed. With age hardening at constant temperatures from a solution heat-treated condition, these alloys may reach a 15 kg. Brinell hardness level on the order of about 170 B.H.N. However, such alloys at the indicated hardness levels will exhibit a maximum tensile strength on the order of about 50,000 p.s.i. in the cast and age hardened condition.

Moreover, the gold-base alloys for the aforementioned applications generally have solidus temperatures below about 1150° Centigrade which limit their use in conjunction with brazing alloys, and the temperatures at which firing of the ceramic materials can be effected. In addition, the problem of thermal expansion generally dictates that a gold-base alloy be formulated for use with a single ceramic composition, and no facile means is provided for adjusting the alloy to accommodate variations in thermal expansion. Existing alloys generally are difficult to cast in thin sections, particularly useful in dentistry, and often castings of these alloys are prone to hot tearing during cooling-down following casting.

It is an object of the present invention to provide novel gold-base alloys with desirable casting characteristics and which age harden to high-strength levels during air cooling from porcelain firing temperatures.

SUMMARY OF THE INVENTION

It has now been found that the foregoing and related objects can be readily attained in accordance with the present invention wherein a noble metal alloy is provided comprising about 67.0 to 87.0 percent gold, about 2.0 to 15.0 percent palladium, about 2.0 to 10.0 percent platinum, about 0.5 to 1.0 percent iron and about 0.5 to 2.0 percent tin, all based upon the total weight of the alloy.

In addition, minor amounts of impurities up to about 5.5 percent of compatible alloying elements may be present including up to about 1.0 percent rhenium, up to about 2.0 percent silver, up to about 1.5 percent zinc, and up to about 1.0 percent indium.

The alloys desirably contain small amounts of rhenium to produce grain refinement and a highly desirable equiaxed structure. Silver, zinc and indium tend to promote fluidity of the alloy while zinc may provide some benefit from the standpoint of hardness. In addition, these several optional alloying elements are beneficial from the standpoint of facilitating predetermination of the coefficients of thermal linear expansion. Full hardness can be developed in this alloy by simple air cooling from temperatures above 980° Centigrade. Generally, cooling to about 100 to 150° Centigrade should be at a rate of about 80 to 130° Centigrade per minute from a temperature above about 980° Centigrade. This air cooling is conveniently effected by dead air cooling wherein the alloy article is supported upon an insulating block and shielded by a cover or the like to minimize convection. Constant temperature age hardening may also be employed by heating the alloy articles at a temperature of about 530 to 545° Centigrade for fifteen to thirty minutes followed by air cooling. If cooling is effected too rapidly by quenching from about 980° Centigrade, the alloy will be in an annealed condition in which cold working is readily accomplished.

The alloys of the present invention vary from light yellow to white, depending upon the ultimate gold content so that they may be used for various applications where color is of significance. It has been found that these alloys are extremely useful for applications where porcelains or other ceramics are to be fired in surface contact therewith as to provide a bonded structure. Porcelains and other ceramics which are fired at temperatures of 870 to 1070° Centigrade may be used readily with the alloys of the present invention to obtain highly desirable composite structures since the cooling rate for the composite articles after firing of the ceramic may ideally fall within the preferred cooling rate for the alloy of the present invention to develop optimum hardness. The nature of the hardening system of the present invention is not fully understood. It would appear that these compositions may be participating in generating the highly desirable results obtained, the first being iron/platinum and the second being iron/platinum/tin. It has been observed that the atomic ratio of iron to platinum must fall within the range of about 0.1:0.1:0.6:1.0, and preferably in the range of about 0.4-0.6:1.0.

Generally, the solidus temperatures of the alloys of the present invention will be in excess of 1180° Centi-
The alloy of the resultant composite structure was found to have a 15 kg. Brinell value of 180 BHN.

Thus, it can be seen that the present invention provides novel gold-base alloys with highly desirable casting characteristics which are susceptible to age hardening to high hardness levels during air cooling. The alloys of the present invention also have advantageously high solidus temperatures and predictable coefficients of thermal expansion which are highly compatible with porcelains and other ceramics used in dentistry, electronics and other industrial applications. These alloys provide composite structures with porcelains and other ceramics offering significant utility in view of their hardness, corrosion resistance and conductivity. Moreover, the alloys of the present invention are useful in other applications wherein relatively high heats are to be encountered such as brazing operations and the like.

Having thus described the invention, I claim:

1. A gold alloy consisting essentially of about 7.0 to 15.0 percent palladium, about 2.0 to 10.0 percent platinum, about 0.5 to 1.0 percent iron, about 0.5 to 2.0 percent tin, 0.0 to 2.0 percent silver, 0.0 to 1.5 percent zinc, 0.0 to 1.0 percent indium, 0.0 to 1.0 percent rhodium, and the balance gold, said gold being present in an amount of about 70 to 87 percent, all based upon the total weight of said alloy.

2. The alloy of claim 1 wherein the gold content is about 78.0 to 85.0 percent, the palladium content is about 8.0 to 13.0 percent, the platinum content is about 4.0 to 8.0 percent, the iron content is about 0.7 to 1.0 percent and the tin content is about 0.9 to 1.4 percent.

3. The alloy of claim 1 wherein the atomic ratio of iron to platinum is about 0.4–0.6:1.0.

4. The alloy of claim 1 wherein the tin content is about 0.33 to 1.0 percent of the total weight of said alloy.

5. The alloy of claim 1 wherein the atomic ratio of iron to platinum is about 0.4–0.6:1.0, and wherein the iron content is about 0.33 to 1.0 percent of the total weight of said alloy.

6. A structure comprising an element formed from a gold alloy consisting essentially of about 7 to 13 percent palladium, about 10 to 20 percent platinum, about 0.5 to 2.0 percent iron, about 0.5 to 2.0 percent tin, about 0.0 to 2.0 percent silver, 0.0 to 1.5 percent zinc, 0.0 to 1.0 percent indium, 0.0 to 1.0 percent rhodium and the balance gold, said gold being present in an amount of about 67 to 87 percent, all upon the total weight of said alloy and a ceramic element bonded thereto formed by firing against the surface of the alloy element a ceramic material selected from the group consisting of porcelains, glass and enamels.

7. The structure of claim 6 wherein said alloy has a gold content of about 78 to 85 percent, a palladium content of about 10 to 20 percent, a platinum content of about 4 to 8 percent, an iron content of about 0.7 to 1.0 percent and a tin content of about 0.9 to 1.4 percent.

8. The structure of claim 6 wherein said alloy element has a 15 kg. Brinell value in excess of 175 BHN.

The alloys of Examples 1–5 were cast at temperatures of 1315 to 1650° centigrade without evidence of any degradation in hardenability from the as-cast condition. The alloy of Example 2 in the cast and as hardened condition was found to have an ultimate tensile strength in excess of 90,000 psi. The several alloys were found to have desirable castability and the castings were found to be free from hot tears.

Exemplary of the higher solidus temperature of the alloys of the present invention are 1188° centigrade for the alloy of Example 2, 1173° centigrade for the alloy of Example 4 and 1232° centigrade for the alloy of Example 5. Exemplary of the predictability of the coefficient of thermal linear expansion is the fact that the thermal coefficient for the alloy of Example 1 was predicted and experimentally determined as 1.4×10⁻⁶ C⁻¹ and that of the alloy of Example 2 was similarly predicted and experimentally determined as 1.4×10⁻⁶ C⁻¹.

Example 11

A feldspar porcelain without any binder was coated upon the surface of a casting of the alloy of Example 2. Following firing at a temperature of 926° centigrade, the composite was placed on an insulating block and covered by a Pyrex breaker so as to minimize convection currents.