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#### PREFERRED EMBODIMENTS OF THE INVENTION

In accordance with conventional electroless copper plating methods, a substrate is suitably cleaned in an aqueous alkaline solution. The cleaned substrate can be sensitized in a variety of media. A preferred sensitizing solution is an aqueous composition containing 160–165 grams of stannous chloride dihydrate, 170–175 cc. of reagent grade hydrochloric acid, and 1 gallon of distilled water. This sensitizing solution should be maintained at a temperature of from 70–80° F. The substrate is immersed in this solution for 5 to 7 minutes. It is contemplated that the substrate may also be sensitized by immersing them in the following types of solutions: an aqueous hydrochloric acid solution of titanium trichloride; an aqueous ammonium hydroxide solution of silver nitrate; an aqueous solution of hydroquinone and ethanol; and an aqueous composition of stannous fluoroborate and free fluoroboric acid.

Following the sensitizing treatment, the substrate is rinsed in water and immersed in an activating solution, the purpose of which is to deposit a film of a seeding metal onto the substrate. The preferred activating solutions will deposit either gold, silver or palladium. An activating composition is prepared by adding 0.3 to 2 grams of  $\text{PdCl}_2 \cdot 2\text{H}_2\text{O}$ , dissolved in a distilled or deionized water, to 40 to 160 cc. of concentrated reagent grade HCl. This solution will be maintained at a temperature of from 70° F. to 80° F. The substrate is immersed in this solution for 2 to 4 minutes.

Thereafter, the substrate is immersed in the plating bath comprising, for example, an aqueous solution containing a salt of copper and an alkali metal hydroxide in the presence of salts such as potassium sodium tartrate, and/or sodium carbonate. The substrate is immersed for a time sufficient to form a conductive coating.

The instant invention may be carried out by using any conventional aqueous electroless metal plating bath solution. For example, a nickel or copper electroless plating bath may be used. An example of one suitable copper plating bath is as follows:

Component	Lower limit	Upper limit
Copper sulfate pentahydrate, g./gal. ....	165	175
Formaldehyde (37%), ml./gal. ....	1,880	1,900
Nickel chloride hexahydrate, g./gal. ....	63	72
Sodium hydroxide, g./gal. ....	152	162
Rochelle salts, g./gal. ....	695	710
Sodium carbonate, g./gal. ....	68	77

A typical electroless Ni bath may be prepared as follows:

$2\text{NiCO}_3 \cdot 3\text{Ni}(\text{OH})_2 \cdot 4\text{H}_2\text{O}$ —10 g./l.  
 HF (as 50% HF)—6 ml./l.  
 Citric acid—5.5 g./l.  
 $\text{NH}_4\text{HF}_2$ —10 g./l.  
 $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$ —20 g./l.  
 $\text{NH}_4\text{OH}$ —30 ml./l.  
 pH—4.5–6.8  
 Temperature—170–180° F.

The  $\text{Al}_2\text{O}_3$  ceramic substrates used in this invention are prepared by standard techniques. For example, a binder of glass and  $\text{Al}_2\text{O}_3$  powder is mixed with an organic binder and rolled into sheets. The sheets are heated to a temperature sufficient to burn away the organic binder and then fired at a temperature sufficient to melt the glass component and the resultant sintered substrate is cooled. Other pure  $\text{Al}_2\text{O}_3$  substrates are made by sintering the  $\text{Al}_2\text{O}_3$  itself.

Typically, the method of this invention may be carried out as follows:

A one-half inch square substrate of sintered alumina ( $\text{Al}_2\text{O}_3$ ) having a thickness of about  $\frac{1}{16}$  inch is suitably cleaned by dipping in an alkaline solution, e.g., 8 oz./gal.

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of K-2 (an alkaline cleaning solution prepared by The Pennsalt Co.). The solution is heated to a temperature of about 60° C. and the substrate is allowed to remain therein for about 2 minutes. The alumina substrate is rinsed in water and then immersed for one minute in a concentrated sodium hydroxide solution containing about 50 grams of NaOH per 100 ml. of water. Upon removal of the alumina substrate from the alkaline solution it is heated for about 5 minutes at a temperature of about 170° C. to remove water and to thereby deposit a coating of NaOH on the surface of the substrate. The NaOH coated substrate is then heated for about 10–15 minutes at temperature sufficient to melt the NaOH on the substrate surface, e.g., between 318° C. to about 1000° C. Optimally, it is heated in a temperature range of about 450° C. to about 500° C. After cooling, to about room temperature, the substrate with its coating of solid NaOH is rinsed in water to remove most of the NaOH and thereafter rinsed in a dilute acid solution, e.g., a 20% solution of HCl,  $\text{H}_2\text{SO}_4$  or  $\text{HNO}_3$  for about 2 minutes. The substrate is finally thoroughly rinsed in water with ultrasonic agitation.

The so treated alumina substrate is sensitized, activated and placed in a conventional copper electroless plating bath such as hereinabove described for about 20 minutes. It was found that a well adhered copper coating of about 0.00025 inch thick was deposited upon the alumina. Then, the treated substrate is immersed in an electrolytic plating bath thereby having a copper layer electrolytically deposited.

Alternately, the cleaned substrate is immersed directly into the molten alkali metal salt. The alkali metal salt is heated in a container above its melting point, e.g., between 318° C. and 1000° C., preferably, at about 450° C. to about 500° C., and the substrate is immersed therein for about 10–15 minutes. This direct immersion technique eliminates the above steps of heating to deposit an alkali metal hydroxide coating on the substrate and thereafter causing the alkali metal hydroxide to become molten.

Bonding tests were made to determine how strongly the copper coating adhered to the alumina. The pull test on 150 mil diameter copper dots gave values of up to 85 lbs. i.e., sufficient energy was applied in trying to remove the copper dot to break the substrate. The 90° peel test indicated bond strengths of 6 to 8 lb./inch.

While the invention has been illustrated to specifically show its applicability using NaOH, it should be realized that other alkali metal hydroxides can be used. For example, LiOH or KOH may also be used to advantage. Although alumina has been illustrated as a typical ceramic substrate, it is clear that other ceramic materials can be used. For example, zircon, beryllia, steatite or silicate glass-ceramics can be used for the same purposes and treated in the same manner as is described in the instant invention. Further, it should also be realized that while the examples of this invention have indicated heating of the substrate to 170° C. for a period of 5 minutes to remove water and thereby deposit the alkali metal hydroxide on the substrate, other temperatures and times can be used. It is readily apparent that lower temperatures would require heating for longer time periods and vice versa. It should therefore, be apparent to those skilled in the art that other variations of the invention readily present themselves and are incorporated herein.

What is claimed is:

1. A method for electrolessly depositing a strongly adhering layer of metal on the surface of a ceramic substrate comprising the steps of:

- (a) cleaning said substrate by immersing the same in an alkaline cleaning solution;
- (b) rinsing said substrate in water;
- (c) depositing a coating of an alkali metal hydroxide on the surface of said cleaned substrate by immersing said substrate in an alkali metal hydroxide solution and thereafter heating the substrate at a tem-