Nickel Plating of Metallized Aluminum Nitride Substrates for Electronic Applications

ABSTRACT

This is a technical note explaining the application of plating on aluminum nitride using two thermally decomposed thick inks containing Mo/Mn or W as the metal and glass forming agents. An actual plating method is presented, including the critical step, activation.

Introduction

The increased use of ceramic substrates for electronic devices and the need for a very small, fine printed circuits with very high circuit density has created demand for improved ceramic materials. Greater thermal conductivity is a prime consideration. High dielectric constant, good physical strength and low coefficient of expansion are required.

Aluminum nitride (AIN) provides these requisites.

Because of the special characteristics of aluminum nitride, such as sensitivity to alkaline environments, and low surface porosity, special preparation and plating chemicals are required to metallize and plate circuits. Plating is essential to improve conductivity, provide corrosion protection and allow joining and mounting of components.

PROCESS

Aluminum Nitride (AIN) is a new substrate that has been developed for use in electronic packaging applications. AIN is non-toxic, has a high thermal conductivity as high as 200 W/in.\(^0\)K., and has a coefficient of thermal expansion, which is close to Si\(^1\). Because of these properties, it has a very large potential for high power application\(^2\).

Refractory metallization is accomplished by using thick film inks, which contain Mo/Mn or W as the metal and glass forming agents. Detailed information on metallizing including mixing and firing procedures is beyond the scope of this paper, but can be found in references 4 and 5. Two metallizing inks were used to metallize the AIN (Supplied by Exact Electroplating Engineering Co., Carson, Ca., as brand names: FKM and FKW) with Mo/Mn and W.

In electronic packaging assembly, the substrate is usually brazed or soldered to other metallic components. In addition, the active die must be attached to the substrate for heat dissipation. This necessitated the development of a suitable plating process for metallized AIN.

Electroless nickel phosphorus or electroless nickel boron can be plated\(^6\) instead of sulfamate nickel using the same preparation steps including the woods nickel strike. The metallizing materials are known to be hard to plate, because they are not normally catalytic to electroless nickel. Therefore, before electroless nickel can be properly deposited, the metallized surface must be subjected to specific pre-cleaning and treatment cycles. For isolated circuit elements, catalytic activation of the metallized layers can be used to substitute for the Woods nickel strike. For example, 0.1 g/l palladium chloride solution used at 20-25 degrees C, for 30 seconds will catalyze and metallize it for electroless nickel plating. A water rinse follows, then 5% v/v hydrochloric acid dip, 1 minute, followed by DI water rinse, then electroless nickel plate.

An acid cleaner was chosen as the soak cleaner. Various acid cleaners composed of either inorganic acids, along with water-miscible solvents and organic wetting and emulsifying agents were used. Typically, these cleaners are obtained from printed circuit board chemical suppliers. All temperatures were at 110\(^0\)F.

The activation of the Mo/Mn or W metallization was cathodic in a solution of 8 oz/gal ammonium bifluoride and 8 oz/gl of sodium bisulfate. The temperature was room temperature. Current density was 50 amps/ft. Anodes were graphite. Total activation time was 1 minute. The addition of the ammonium bifluoride is to etch away any glass on the surface of the Mo/Mn or W metallizing. Any glass remaining on surface will cause blistering problems during a subsequent assembly.

The Wood’s Nickel strike had a formulation of 64 oz/gl nickel chloride and hydrochloric acid at 32 oz/gl. The nickel strike is operated at room temperature using nickel anodes. A current density of 20 amps/ft\(^2\) was used for duration of 3 minutes.

Sulfamate nickel plating was operated using standard formulations; 60 oz/gl nickel sulfamate, 4 oz/gl boric acid, 1 oz/gl nickel chloride, pH 4.15, temperature of 135\(^0\)F, and nickel anodes. Current density was 8 amp/ft\(^2\). Typically, 50-150 microinches of nickel was plated.
After nickel plating was completed, brazing Kovar pins with a Cu/Ag braze carried out adhesion testing. The brazed pin was attached to a pull tester and then tested. At 10 kg/mm$^2$ (15,000 psi) the pin pulled away from the substrate with attached metallizing and ceramic. This indicated that the ceramic fractured before the nickel plated separated from the metallization.

**SUMMARY**

Satisfactory metallization and plating can be achieved over aluminum nitride using special non-alkaline preparation and plating processes.

**References**


