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Reliability of Contact Surface Finishes

The durability and corrosion resistance of nickel/gold electrodeposits renders a reliable contact surface finish. There are gold electroplating processes that can produce a 99.9-percent gold electrodeposit, with a hardness of 150 Knoop. A low-stress nickel deposit between the gold overplating and copper contributes a diffusion barrier to prevent alloying of copper and gold.

This type of contact surface is in accordance with Mil-G-45204, Type II, Class 1. The deposit hardness and wear-resistance are enhanced by adding complexes of cobalt, nickel or iron to the bath makeup. A coating of 99.8-percent gold yields excellent corrosion resistance—ideal for a contact, but not suited for wire bonding.

Non-precious Metal Contact Surfaces

Tin and tin/lead alloys have been successfully employed to enable a low-cost solderable surface on connector pins. There are problems associated with pure tin electrodeposits, however, which must be addressed.

Tin Transformation

This phenomenon is known as tin "pest" or tin "disease," and is an allotropic modification of tin to beta tin. This form of tin is associated with volume expansion and powdering of tin when subjected to temperatures below freezing.

Tin Whiskers

This is an occurrence where pure tin coatings have a potential of relieving stresses by producing filament growths, which could cause shorting in electronic circuits. Numerous studies have proven

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that this rare, but potentially dangerous phenomenon can be avoided by alloying with at least two-percent lead. Alloys of more than 12 percent lead are not recommended, because contact resistance increases rapidly with higher lead contents.

As a result of these investigations, the connector industry began specifying a 93-percent Sn, seven-percent lead (±5%). The seven-percent lead was considered ideal for avoiding both problems.

Fretting Corrosion

Another dilemma that must also be considered is a failure mechanism known as fretting corrosion. The term "fretting" refers to repetitive sliding movements between surfaces. Applications to be avoided are those involving low-frequency vibration, a long wipe distance/cycle, a low-contact force and a contact geometry where debris is easily trapped under contacts.

The combination of fretting and oxidation—fretting corrosion—is characterized by the presence of black spots at the point of motion. The spots indicate a buildup of tin oxide debris. Debris augments contact resistance, sometimes to the point of opening the circuit.

Fretting does not always degrade electrical continuity, however. The determining factor is the motion itself. The fretting mechanism develops in stages. The first time fresh contacts are mated, the plastic deformation of plating causes metal-to-metal contact. In the next stage, oxide debris is produced on the contact surfaces as a result of fretting movements.

As the sliding movement continues and tin oxide buildup increases, the final stage of the fretting mechanism is reached, whereby the accumulated debris insulates the interfaces, magnifying contact resistance.

To circumvent this problem, a high-contact force will reduce sliding and provide contact resistance stability, but may accelerate wear. Contact lubrication reduces wear by decreasing the coefficient of friction, floating debris from contact area, and preventing oxidation of the exposed metallurgy. A downside of lubrication, however, is attraction of dust and lint on contact surfaces.

The shape of the contact points will have a bearing on fretting behavior, and consequently on geometry control of normal force, tendency to trap debris under contacts, and the number of contact points available for conduction. Wedged-shaped contacts seem to provide the best contact performance.[1]

Plating Issues

Contact durability is dependent on hardness and thickness. A thickness of at least 0.0001-in. (0.0254 mm) is suggested as a minimum. An underplate of nickel prevents formation of copper-tin intermetallic by providing a barrier layer, and also prolongs wear life.[2]

Summary

Tin and high-tin alloys offer a reliable, low-cost alternative to precious metal surface finishes for electrical contacts in many applications, as long as conditions associated with tin transformation, tin whiskers and fretting corrosion are understood and avoided. **P&SF**

References

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2. A. Lee, M. Mamrick, "Fretting Corrosion of Tin Plated Electrical Contacts," *Material Issues Advanced Electronics Opto-Electronic Connectors*, 71–87 (1991).