TECHtips

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Electronics Manufacturing Insights from ACI Technologies, Inc.

Platings for Interconnections

Types of Interconnects

Interconnection technology relies very heavily on the ability of the conductors on a printed wiring assembly to maintain reliable signal integrity. Harsh environmental factors can precipitate a loss of conductivity due to oxidation and corrosion. Connections are typically soldered or inserted using pressure fitted connectors to obtain enough surface contact to meet the electrical conductivity requirements. In pressure contacts, surface integrity is especially critical where the abrasive effects of retraction and insertion can wear off the metallic finish from the contact area. This can expose the underlying copper or nickel and lead to increased resistance at the contact points. These types of conductors are frequently found in card edge connectors where the terminations are plated with a layer of nickel and gold (frequently referred to as gold fingers). A hard gold is typically used containing very small amounts of nickel and cobalt to increase the wear resistance.

The Function of Surface Finish

The surface finish of an electronic interconnection is defined by its requirements for solderability, corrosion resistance, contact resistance, and wear resistance. The most popular surface finish for solderability is, of course, tin-lead solder. However, this has drastically changed with the requirement of lead-free electronics. Unfortunately, the alternative usually selected is pure tin. A finish of pure tin electroplate or immersion tin has the propensity for growing tin whiskers over the product lifetime. A typical example of this is evidenced by the Government-Industry Data Exchange Program (GIDEP) alert issued by NASA. This involved a commercial-off-the-shelf (COTS) connector that was electroplated with pure tin in 2007 and already displaying tin whiskers at incoming inspection at NASA in 2009. Another example of this is shown in Figure 1.

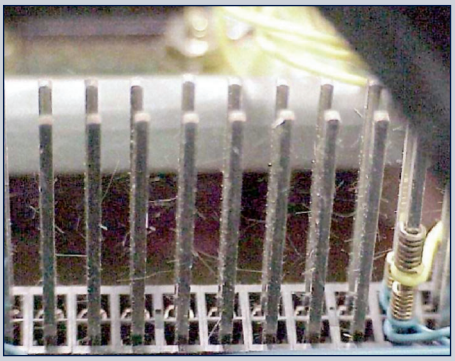

Figure 1: Pure tin plated connector pins displaying many short circuits due to tin whisker growth. Connector was approximately 10 years old. Photo courtesy of NASA.

Corrosion resistance has also been affected by the European Union's Restriction of Hazardous Substances (RoHS) Law. Olive Drab Cadmium (OD Cad) had been used for many years as a superb salt-spray resistant coating for connectors, but has since been banned for all but purely military applications by the European Union's RoHS law. In 2001, even before RoHS, 1.3 million Sony Playstations were blocked from sale in the Netherlands since their electrical power connector had not been changed from the cadmium plated version.

Contact resistance of a base metal can be significantly modified by electroplating, electroless plating, or immersion plating with thin layers of various lower contact resistance metals. For example, electroless plating of copper or steel connectors with nickel, gold, or palladium can drastically lower the contact resistance of the connector pin or socket base metal, and this can appreciably improve the electrical performance of the connector. An example of this was the plating of magnetic electro-mechanical telephone switch contacts with rhodium by the Bell System, resulting in the lowest possible maintenance mechanical switch for the telephone system. For higher currents, silver is often electroplated on the pins and/or sockets of electrical connectors for its simultaneous low contact resistance and good wear properties.

Finally, wear resistance in a connector will be affected as much by the surface finish plating as the base metal. The classical case of this is seen in connectors having steel pins and sockets for low cost and high strength, but then is plated with thin coats of gold, silver, or nickel for good contact resistance and wear properties. Circuit cards often have surface conductors at the edge of the card (edge card connectors) that are electroplated with a cobalt-hardened gold electroplate for multiple insertions into connectors in a backplane, reducing the need for a separate connector piece part to be soldered to the board. This cobalt-gold plating is simultaneously low contact resistance, and high wear resistance for this application.

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Finish	Thickness	Hardness	Purity	Contact Resistance	Applications
ENIG	0.1 micron Gold over 5 micron nickel	N/A	99.9% Gold	0.03 ohms	Used as oxidation protection for subsequent soldering operations
Soft Gold	2-4 microns Gold over 5 micron nickel	90 Knoop	99.9% Gold	0.03 ohms	Good for pressure contact and wire bonding applications
Hard Gold	1.5 micron Gold over 5 micron nickel	130-220 Knoop	99.7% Gold	0.05 ohms	Best for edge connectors, surface rotary switches, and on-off contacts

Table 1: Commercial finish application guideline.

Requirements of Connector Finishes

The specified requirements for connector shell, pin, and socket surface finishes usually center around four qualities of the surface finish. A hard gold finish is typically used for connector applications subjected to insertion pressures such as edge cards and connector pins. In some cases softer gold may be used, but this generally restricted to aluminum and gold wirebonding applications. It should be noted that the harder the gold, the less pure, and the more susceptible the hardening agents in the gold are to high temperature oxidation.

There are three MIL SPEC (MIL G-45204) categories of gold purity and four classifications of gold hardness. Additionally, thickness requirements for both the underlying nickel and gold will be a function of the specific application. Table 1 is a guideline representative of good commercial practice.

Thickness is generally measured using X-ray fluorescence (XRF), although it can also be determined using a profilometer, requiring a step of plating immediately adjacent to non-plated area.

Hardness is usually determined using a diamond indenter and measured on the Knoop scale in accordance to ASTM B 578.

XRF can be used to distinguish alloy composition. It has become critical in the identification of pure tin plating (which grows whiskers) from tin-lead plating (which does not grow whiskers). This is very critical to some aerospace and defense (A&D) applications, since the two are visually identical, and many vendors of electrical connectors do not change their part numbers when they change from tin-lead plating to the newer RoHS compliant pure tin plating.

Finally, contact resistance is measured using a four-point probe method and a suitable electrometer.

ACI Technologies has considerable experience in plated metal finishes, and significant capability to measure critical parameters of electronic surface finishes. Questions on any electronic applications of such finishes are always welcome on the Helpline at 610.362.1320.

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