2 Connector Design/Selection/Assembly

This chapter will provide an overview of design and material requirements for contact finishes, contact springs and connector housings as well as the major degradation mechanisms for these connector components. Material selection criteria for each will also be reviewed.

2.1 Contact Finishes

2.1.1 Contact Finish Requirements

As noted in Chapter I/1.2.3 Contact Finishes, a contact finish is applied to connector contact springs to provide two basic functions:

- **to protect the copper alloy spring members from corrosion, and**
- **to optimize the mechanical and electrical performance of the contact interface.**

Corrosion

As noted in Chapter I/1.2.2 Contact Springs, connector contact springs are generally made from copper alloys due to their combination of high electrical conductivity and formability at reasonable strength levels. Unfortunately copper alloys are susceptible to corrosion in environments containing oxygen, sulfur and chlorine, in other words typical connector operating environments. Thus, the first function of a contact finish is to protect the copper alloy spring from corrosion.

Corrosion protection can be provided by simply coating the contact spring with a material which is not susceptible to corrosion or, in connectors, a material which forms films which are self limiting in thickness and readily displaced mechanically during the mating of a connector. **Gold is the prime example of the first case and tin of the second.** Each of these cases will be discussed later in this chapter.

"Optimization" of contact interface performance is provided by influencing the corrosion and wear characteristics of the contact interface. Corrosion protection is necessary in order to ensure that metal-to-metal a-spot contact interfaces can be created and maintained as discussed in Chapter I/1.3.1 Overview. **Recall that chapter. We also note that creating and maintaining a metal-to-metal interface is the prime goal of connector design. A gold-to-gold contact interface is intrinsically metal-to-metal because gold does not corrode. A tin-to-tin contact interface becomes metal-to-metal when the surface tin oxide is displaced on mating of the connector.** There are some qualifications to this simple description that will be discussed later in this chapter.

Wear

"Optimization" of contact interface wear characteristics is particularly important with gold contact finishes. The concern is that the wear that occurs on each mating cycle can result in **wear through** of the contact plating exposing the underlying copper alloy which is then susceptible to corrosion. The wear performance of gold finishes can be improved by increasing the hardness of the gold by alloying and by increasing the effective hardness of the gold by using a nickel underplate.

Consider noble metal finishes first.

2.1.1.1 Noble Metal Finishes

Connectors using noble metal finishes, usually gold, can be used in all applications and environments. Because they are more expensive than connectors of similar designs using non-noble finishes, due to the cost of gold plating, they are not generally used in commercial applications. They are, however, specified in most computer and telecom applications due to their performance advantages.

A noble metal contact finish is a system consisting of:

- **a noble metal surface, usually gold**
- **a nickel underplate and**
- **the contact spring base metal (copper alloy)**

All three elements influence both the electrical and mechanical characteristics of the contact interface.

Electrically the noble metal surface allows for the formation of the metal-to-metal a-spots that create the electrical contact interface; the nickel underplate provides benefits that protect the nobility of the contact interface due to external corrosion mechanisms; and the constriction resistance takes place in the contact spring material.

Wear

Mechanically it is the contact surface that will experience the wear process directly; the hardness of the nickel underplate improves the wear resistance of the system; and the hardness of the base metal contact spring influences the overall amount of deformation that occurs. This effect of the contact spring on deformation is due to the low thickness of the gold and nickel platings, of the order of microns, so that the stresses applied to the contact interface penetrate into the contact spring.

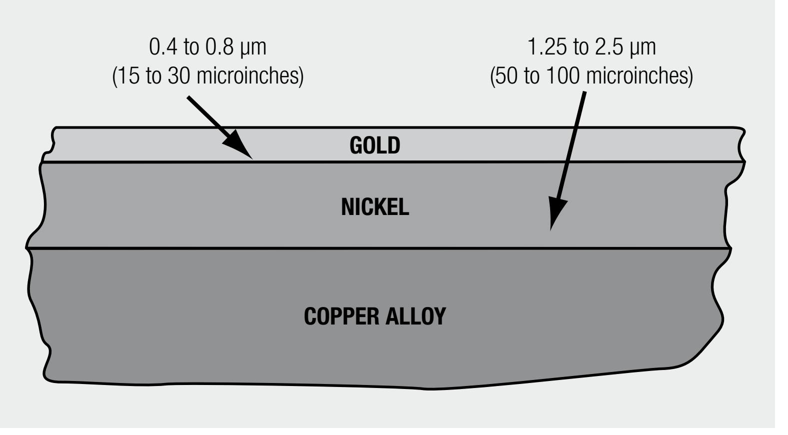

Fig. 2.1: Noble metal contact finish

Figure 2.1 schematically illustrates a cross section of a noble metal finish. The noble metal surface plating is usually gold. In computer/telecom applications the gold is typically electroplated to thicknesses of the order of 0.4 to 0.8 µm (15 to 30 microinches). The gold plating used in connectors is typically a "hard" gold. Hard golds are lightly alloyed, 0.1 percent, with cobalt, nickel or iron, with cobalt being the most common.

Palladium alloy

Gold flash

There is an alternative noble metal finish using palladium alloys. The most common palladium alloy is palladium (80)-nickel (20) with palladium (80)-cobalt (20) also used. In this case the bulk of the plating thickness is palladium alloy, but the surface plating may be a gold flash. A flash is a thin plating of the order of a tenth of a micron (4 microinches) in thickness.

The nickel underplate is typically electroplated to thicknesses of 1.25 to 2.5 µm (50 to 100 microinches). Recall from Chapter I/1.2.3 Contact Finishes that the nickel underplate provides several benefits with respect to corrosion and wear which will be discussed in Chapter II/2.1.2 Contact Finish Degradation Mechanisms.

Whisker:

Whiskers

Whiskers are single crystal fibres (when pure Tin plating is used) which can cause electrical failures. Lead was a good way to prevent them as there was no Tin whisker problem while Sn-Pb was the major plating used in the connector industry.

Whisker density, length and shape are quite different and unpredictable and can lead to transient or permanent shorts in electric and electronic circuits. Either directly on the component where they have grown or (if they break loose) somewhere else in the circuit.