1.5 Connector Materials and Processes

This section will provide a basic discussion of connector materials and manufacturing processes. It will give insights in contact finishes with electroplating as well as copper alloy metallurgy.

1.5.1 Contact Finish Electroplating

The majority of connector contact finishes are applied by continuous electroplating of reels of stamped and formed contacts with tin, tin-lead, silver and gold over nickel plating's in thickness ranges from 0.1 to 5.0 µm (4 to 200 micro-inches). Three plating practices will be described, overall, selective and duplex. In **overall plating** the entire contact surface is plated with a single material; tin finishes are often overall plated.

In **selective plating** the plating is applied only to defined functional areas of the contact; gold plating is generally done selectively, with the gold applied only at the portion of the plug and receptacle contacts that define the mating interface. In **duplex plating**, different plating's are applied at the separable connection and termination portions of the contact. The most common duplex plating is tin at the termination end, for soldering, and gold over nickel at the separable connection end. Electroplating and selective/duplex plating practices are highly proprietary and only a general description will be provided in this discussion.

1.5.1.1 Electroplating Basics

Electroplating, or electrodeposition, in connector technology refers to the plating of a material, selected for dedicated properties which will be explained deeper in section 1.7 and apply the needed contact finishes onto a contact spring material.

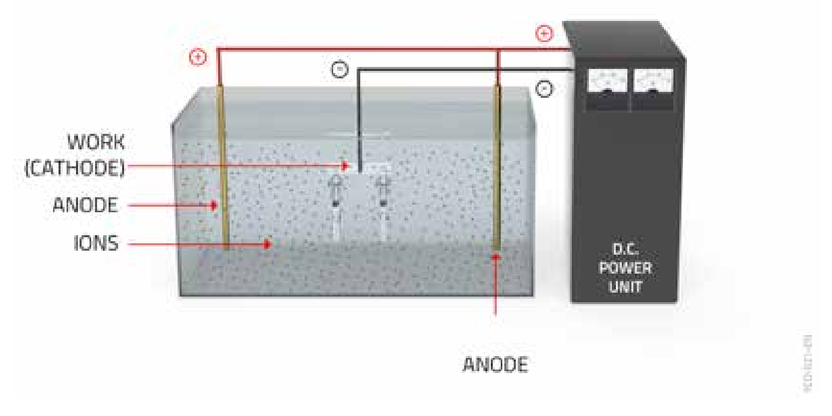

Fig. 1.21: Plating principle

Figure 1.21 schematically illustrates a simple electrochemical plating system. The "electro" part of the system includes the voltage/current source and the electrodes, anode and cathode, immersed in the "chemical" part of the system, the electrolyte or plating bath, with the circuit being completed by the flow of ions from the plating bath to the electrodes. The metal to be deposited may be the anode and be ionized and go into solution in the electrolyte, or come from the composition of the plating bath. Copper, tin, silver and nickel metal usually comes from anodes, while gold salts are usually added to the plating bath in a controlled process to maintain the composition of the bath. The plating bath generally contains other ions to facilitate current flow between the electrodes. The deposition of metal takes place at the cathode.

The overall plating process occurs in the following sequence:

1. Power supply pumps electrons into the cathode.
2. An electron from the cathode transfers to a positively charged metal ion in the solution and the reduced metal plates onto the cathode.
3. Ionic conduction through the plating bath completes the circuit to the anode.
4. At the anode two different processes take place depending on whether the anode material is soluble, the source of the metal to be plated, or insoluble, inert. If the anode material is soluble, a metal atom gives up an electron and goes into the solution as a positively charged metal ion replenishing the metal content of the plating bath. If the anode is inert a negatively charged ion from the plating bath gives up an electron to the anode.
5. The electron flows from the anode to the power supply completing the circuit.

Note that the deposition of metal at the cathode requires an electron so the rate of deposition depends on the flow of electrons, that is, the current flowing from the rectifier. The thickness of the deposit, therefore, depends on the current and the length of time the current is applied. This relationship is a result of Faraday's law which relates the weight of a substance produced by an anodic or cathodic electrode reaction during electrolysis as being directly proportional to the quantity of electricity passed through the cell.

While Faraday's law fixes the amount of metal deposited, the distribution of that metal is dependent on the distribution of the current. This fact allows for selective deposition of the metal, a process commonly used in connector contact electroplating. Figure 1.22 schematically illustrates the relationship between current distribution and deposited metal thickness. The same amount of current flows in the two geometries so the total metal deposited is the same, but the distribution is very different. The anode and cathode geometries and spacings in connector electroplating practice are designed to shape the current flow between the anode and cathode so as to control the deposition of the finish material, both thickness and distribution, onto the contact. This capability is critical to the successful implementation of selective and duplex plating processes. The sizes, shapes and distance between electrodes are among the proprietary processes of connector electroplating. Plating bath compositions and applied current practices may also be proprietary.

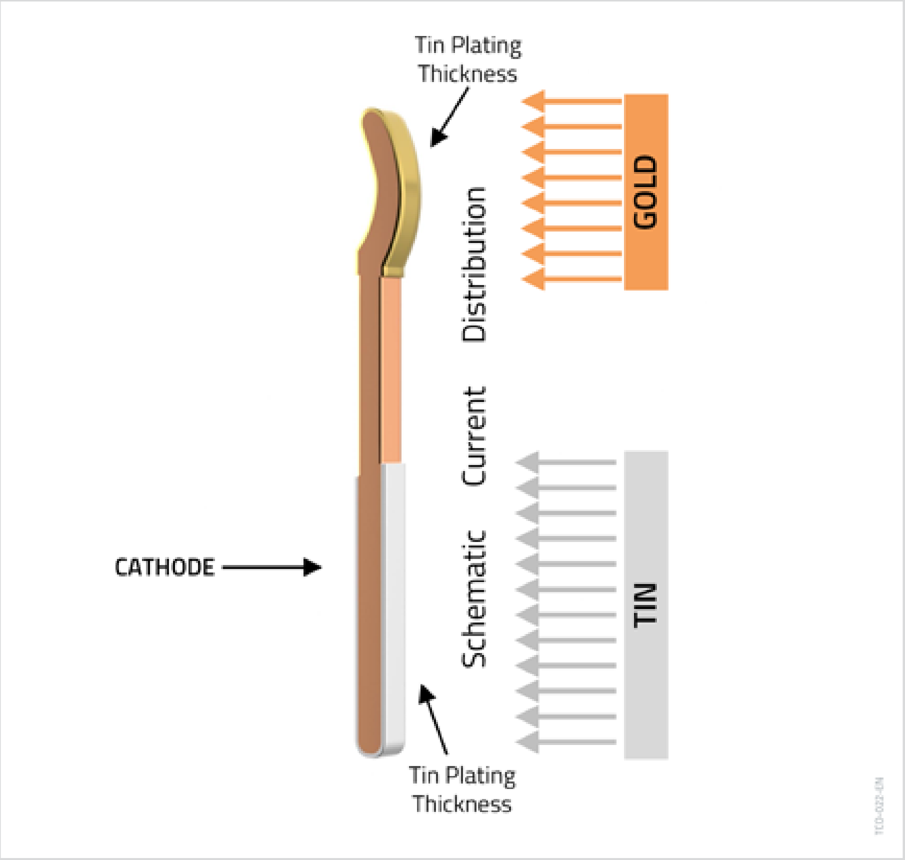

Fig. 1.22: Current distribution – metal thickness

1.5.1.2 Reel-to-Reel Strip Plating

The following discussion provides a basic overview of the stages of electrodeposition during a reel-to-reel strip plating process. The function of each stage will be described, but the details of accomplishing the function are not included because, as noted previously, electroplating practices are highly proprietary.

Stage 0 – Incoming inspection:

The quality of the electroplated coating is directly related to the quality of the incoming roll. Successful electroplating requires a "clean" metal surface: the material to be electroplated must not have any residues of punch oil, scratches or punch damage, otherwise a smooth, continuous and defect-free coating will not be produced.

Stage 1 – Precleaning:

Given the previous comment on surface cleanliness it is not surprising that the first stage of the electroplating process is to clean the contacts. Many different cleaning processes may be included in this stage, ultrasonic organic cleaning to remove residual stamping oils or contaminants, acid, electrocleaning/electropolishing etc. A rinsing station may be included between each of the cleaning stages as well. Cleanliness is critical to electroplating success.

Stage 2 – Plating:

The selected metal is now electroplated onto the cleaned contacts. While the need for a nickel underplate with gold contact finishes has been emphasized, there are other reasons for using an underplate with other finishes. For example a thin layer of copper may be applied as a "strike" to facilitate adhesion onto some copper alloys, or a thicker layer may be used to smooth the surface, a levelling copper. The same electroplating practices will be used for these supplementary plating as for the finish plating. Plating bath pH , composition and temperature need to be carefully monitored during the electroplating process.

Stage 3 – Rinse/Dry:

On completion of electroplating the contacts are rinsed and dried before being re-reeled and sent on to the next stage of the manufacturing process. Rinsing is important because residual plating solution and salts can cause corrosion of the contacts if not removed.

Multiple "Stage 2" stations can be used for multiple layer plating's, gold over nickel, and, if so, it is necessary to ensure that the plating solutions do not transfer from one station to the next so a rinse station is generally included between all plating stations. In the case of gold over nickel plating's, it is essential that the contacts do not dry out between the nickel and the gold stations because nickel exposed to air "passivates", forms a thin oxide layer, inhibiting the effective plating of the following gold plate.

A few comments on selective and duplex plating are in order at this point. Figure 1.23 illustrates a contact which is both selectively and duplex plated. The first plating applied is an overall nickel underplate, that is, the entire contact surface is plated with nickel. The second plating applied is a selective gold at the mating interface, a. The third plating is a selective tin, b, at the contact tail to provide a solderable surface.