Plated and Solder Dipped Finishes for Semiconductor Components

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Plated or hot-solder-dipped coatings have been used for semiconductor component external solder terminations for many years in both commercial and military applications. In most cases this has required electroplating of tin, tin-lead, nickel-silver, or nickel-gold for subsequent solder connections to external terminations, or simply hot-solder dipping of tin-lead over a copper, nickel, or silver base metal. As these evolved over the years, the most common coatings today are either a final hot-solder dip or electroplated tin-lead finish. However others are still used where specific requirements or economics justify there use.

Tin coatings alone are now used less frequently. In the 1980s it was found that undesirable side effects such as "tin-whisker" growth could occur, particularly if deposited with "bright tin" methods that created smaller sub-micron grain sizes and stresses within electro-deposited layers. It was also determined hot dipping or reflow above the melting point of tin would greatly diminish this whisker problem by removing small tin-grain structures from the whisker-prone submicron range. More importantly it was determined that the addition of a minimum of 2% lead (Pb) to electroplated tin (Sn) layers would eliminate the whisker problem.

With these notable tin-lead advancements, the specific reasons for selecting either electroplated or hot-solder dip tin-lead as a preference has often simply been affected by device configurations and manufacturing process control or automation advantages for various products. These include package materials and designs that influenced tin-lead coating or thickness required for good quality solderability. For example it has been found that solderability performance over prolonged periods of shelf life can be improved by having at least 300 µinches of tin/lead with an optimum thickness in the range of 400 to 500 µinches. This can be particularly important if tin-lead coatings are deposited directly over a copper substrate. In these examples, tin can form an intermetallic with copper that grows with time and temperature (including shelf life) and eventually becomes difficult to solder to. The desirable thicker tin-lead coatings over copper have not been necessary on other substrates such as nickel, silver, or nickel-silver.

Plating thickness and uniformity control is greater with electroplating methods compared to hot-solder dip. The latter typically produces tin-lead coatings in the vicinity of 50 to 120 µinches. Also when terminal configurations are not round and are configured with square leads or "corners" (such as surface mount end caps), these areas receive thinner tin-lead coverage after hot-solder dip with its inherent surface tension effects. These "corner" areas may also affect optimum shelf-life solderability when hot-solder dipped directly over a copper base or other dumet materials involving copper-clad steels for various surface mount packages (such as MELFs). Many older axial-leaded-through-hole devices with round leads have been less sensitive to this phenomenon when hot-solder dipped.

Electroplated tin-lead baths used by Microsemi are typically 5% lead (Pb), and the option of hot-solder dip is typically eutectic solder representing 37% lead. The lead content may accurately be determined by X-ray Fluorescence on devices. However there are other simple ways to quickly confirm a minimal presence of lead in the coated finish by simply using a Potassium Iodide indicator solution. If lead is present, a distinct yellow trace color will become evident.

In other electroplating options, nickel-silver plating has been used for over 25 years on some plastic-transfer-molded products including axial-leaded types. This method is very economical since it requires plating only once on the initial headed-lead pieceparts prior to assembly. This plated finish does not reflow during component solder assembly and requires no further plating again for solderability on the external lead terminals after transfer molding of the device body. However these silver finishes can have their handicaps since they are easily tarnished from pollutants in air or other sulfur-contaminated sources such as paper materials if these products are poorly stored prior to use. In these type examples, devices can be cleaned prior to soldering with various silver cleaning products such as "Kester 5560 Solder Nu".

Tarnishing or oxidation of silver (or other metals) may be avoided with a further coating of either hot-solder dip or electroplating of tin-lead. Also nickel-gold plating options may be considered, however such choices are obviously not as economical. With the noted improvements in shelf life for tin-lead plating or hot- solder dip, the interest in nickel-gold plating options have significantly declined. Also there is concern by users that gold eventually contaminates solder baths to levels that may result in brittle solder joints. Acceptable control limits for this and other undesired metals in solder baths are further described in MIL-STD-2000A.

Other finishing combination options exist such as with tin-lead plating or solder dip over nickel surfaces requiring solderability such as with "solder terminals" on stud devices. In some examples, nickel may be used as a barrier to prevent rust over steel base metals or a barrier to copper in soldering to sensitive silicon die elements with relatively shallow pn junctions. In this latter case for plastic body devices, the exterior tin-lead must then be added after transfer molding where a final finish of nickel would not be desirable since it requires stronger cleaning fluxes or reducing environments (such as hydrogen) to ensure good soldering on PC boards.

There are cost trade-offs in these added processing steps since tin-lead deposition becomes a second plating or solder dipping operation before a product is "finished" for exterior solderability. For these reasons, the earlier described single step nickel-silver finishes have persisted, particularly on axial-leaded plastic components where a nickel barrier for copper is required for the silicon die.

Other component finishes have also been used for semiconductor products, however these are the predominant examples historically provided by Microsemi.

In conclusion, tin-lead coatings have become the most popular finish for shelf life and solderability performance on semiconductor components. Electroplating of tin-lead appears to provide the greater flexibility in overall process control for long-term-solderability features with thicker coatings and superior uniformity over irregular design surfaces. Nevertheless hot-solder dip is also used when device configuration or automation produces the most cost-effective results.