Printed circuit boards-Organic board coatings

Introduction

The term ‘organic board coatings’ covers two distinct types of coating. The first type, and the older of the two, is a relatively thick ‘varnish’ applied to the whole of a tin-lead finished board in order to preserve its wettability during storage. Remnants of the coating are generally removed by cleaning after soldering. [This type of coating must be distinguished from solder resist, a heat resistant organic coating, with openings at the solder lands, which is intentionally non-wettable by solder.]

The second type of organic coating, and by far the most common nowadays, is a vanishingly thin protective coating, applied just to the bare copper, which disappears during the actual soldering process.

Protective coats

There are many proprietary organic coating materials. As they must not obstruct wetting and the flow of solder to the soldering areas, they must either dissolve into or mix with the flux to a sufficient extent. A typical coating is based on modified colophony (the ‘rosin’ used to make fluxes), usually with an acrylate or epoxy ‘film former’ to prevents the colophony from crumbling, which would cause contamination of tooling such as punches or dies. However, on boards with plated through-holes, the use of a film former is less desirable because its presence in the holes tends to retard the filling of these holes with solder.

Such protective coats are applied by roller coating or dipping in a dilute solution, taking care that the surface is clean. The optimum thickness for such coatings is of the order of 0.5mm. This thickness provides adequate protection against fingerprints without hindering the action of the flux. Coating thickness can be determined by weighing a metallic test plate before and after coating, provided that the density of the dried solids of the coating solution is known.

The protective coat will in most cases reduce the wettability slightly, but, in the long term, the wettability is better retained. The qualitative effects of storage time on the wettability of boards, for coated, non-coated, and non-coated but packed conditions are shown schematically in Figure 1.

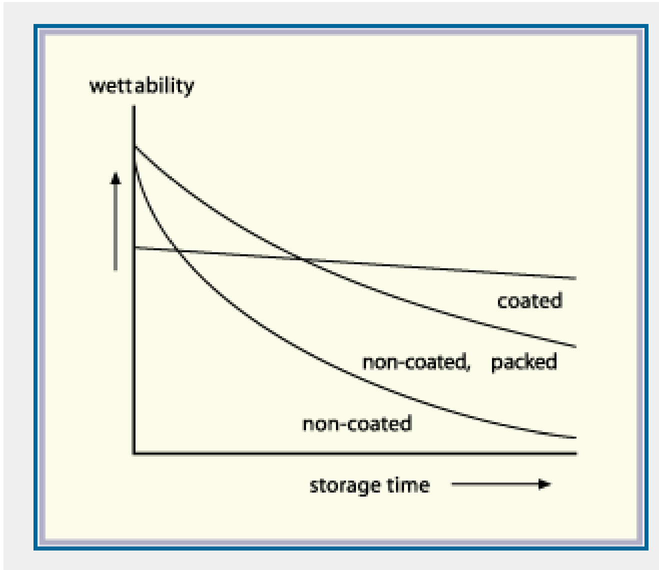

Figure 1: The effects of storage time on the wettability of PCBs

Reasonably good protection is provided if the boards are sealed in polyethylene bags together with silica gel (although polyethylene is not in fact gas-tight). Best results are obtained with laminated bags of polyethylene-aluminium-polyester, but in any case the wettability of the enclosed boards will slowly decrease. The maximum long-term storage life is debatable, but should not exceed two years.

Organic Solderability Preservatives

Bare copper is only solderable when very fresh, and needs protection from oxidation. A number of organic ‘anti-tarnish’ finishes, or ‘corrosion inhibitors’, based on imidazole or triazole compounds, have been found to be effective against undesirable surface reactions on copper and copper alloys. Most are only a few atoms thick and need to be deposited on very clean copper.

Figure 2: A PCB finished with an Organic Solderability Preservative

Carbon contact pads

OSP coatings come in many different formulations, although with similar basic chemistry. The differences include variations in coating thickness, the use of a water base rather than a solvent base, and whether some complex reaction products are involved. Trade names you will come across are 'Entek' (from Enthone) and 'Cuprotec' (from Shipley).

Key issues in the specification and process control for these coatings are:

Whether the base copper remains solderable after multiple thermal cycles – this is needed for double-sided assembly. [Early formulations based on benzotriazole had poor oxidation resistance and did not survive multiple heat cycles]

The thickness of the coating – thicker coatings do not always give enhanced protection and can make it more difficult to test the board.

A typical application process consists of several pre-cleaning and conditioning stages, followed by immersion in a dilute (0.1% by weight) solution of the OSP for 1–3 minutes. This forms a chemical layer on the surface of the copper 2–10nm thick, depending on the formulation.

Figure 1 shows a conveyorised horizontal implementation, but the process can also be used in a vertical mode, dipping the board successively into the solutions. The most critical part of the process is rinsing between the conditioner ('topography enhancement') and OSP stages – surface cleanliness is a concern with all OSP coatings, because contaminants can appreciably reduce the solderability of the board.

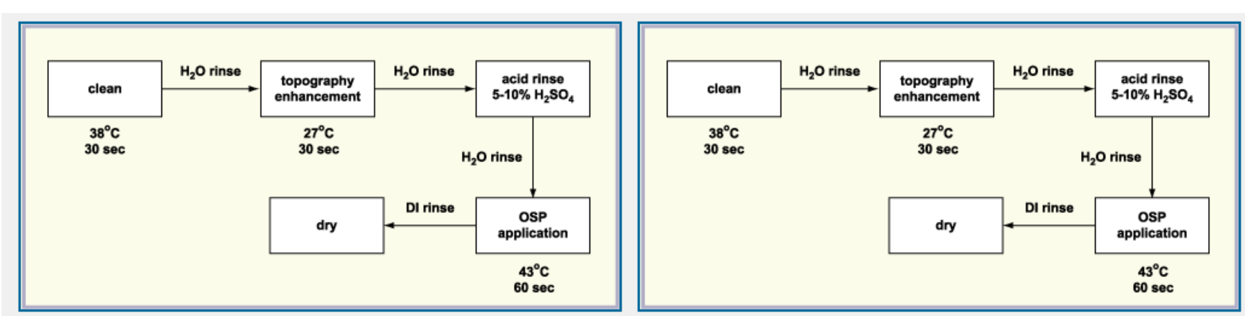

Figure 3: Typical OSP application cycle for horizontal process

Proper control of the process is necessary to ensure a uniform and continuous coating of the correct thickness. The major variables affecting this are the acidity of the solution, the immersion time and temperature, and the concentration of the OSP chemicals. [It has been reported that, with some formulations, even slight over-treatment may reduce the wettability of the copper surface to such an extent that the material becomes unfit to use – the remedy being worse than the disease!]

OSPs compared

Advantages of OSP compared with HASL are that:

there is very much less process maintenance

hazardous waste is avoided

OSP runs with solution temperatures below 50°C, eliminating any possibility of thermal shock.

From the designer's point of view, OSPs give a very cost-effective and flat finish which is suitable for all types of components. OSPs can also be used in applications where the boards need copper pads, yet require other features plated with gold, silver, tin or solder. Water-soluble surface treatment agents based on some imidazoles are able to bond selectively to the copper, providing it with protection, without adversely affecting other metals present, or leaving any film on them.

The shelf life of OSPs is variously quoted, but is of the order of 6-12 months, depending on the environment. It is difficult to produce an adequate accelerated test1 for OSPs, because ageing in steam, or annealing at high temperature, oxidise the copper and degrade the organic coating in a way which is not representative of life. There is no tin-copper intermetallic compound to grow.

1. OSPs have been tested at 40°C/90%RH for 1000 hours to simulate two years of storage; others have tested at 65°C/95%RH for 24 hours and equated this to a shelf life of 12 months. Both predictions assume a model of the deterioration mechanism which is not justified!

Regardless of which finish is used on a board, the pad may not always be wetted by solder all the way up to the edges and corners. This is most commonly found when using no-clean fluxes with low activity. It is very difficult to spot this effect with solder-coated surfaces, but less than total wetting is readily visible with OSPs, because exposed copper can be seen at the perimeter of surface mount pads and through-hole annular rings. There has been concern that such exposed copper could promote copper corrosion, or reduce the SIR of the assembled board under conditions of elevated temperature, humidity and voltage bias. Results, however, show no evidence to support this concern.

Lucent reported2 that the biggest issue in using an OSP coating was not so much the coating itself, but the assembler's inability to be sure that there had not been contaminants on the pad before OSP application. Pads that did not wet at all could be identified, and the joints scraped and repaired, but the possibility that there still remained partially-contaminated pads that appeared to have wet, gave concerns about joint integrity and consequent unreliability.

2. Robert Furrow (Lucent Technologies) postings to IPC TechNet 13 February 2001 and 18 April 2002

Whilst problems were only occasionally experienced, and solderability was poor on just a few pads per board, the cost of reject assemblies could wipe out the benefits of using OSPs. On most occasions, the problems were found not to be the OSP process, but rather things like unseen solder mask residues or incomplete removal of the tin etch resist. However, at least once, boards were shipped without the OSP coating applied.

Lucent also found quality issues when using OSP for via in pad (VIP) designs, where residues or water remaining in the small holes could compromise the OSP coating. Cost and quality issues have convinced several other companies that OSP is non-preferred, and that better results are obtained from a metal finish. Advice given3 is that

Test probes tend to get 'gummed' up frequently from the OSP, so adding all test points to the solder stencil is recommended.

Test fixtures need to be optimised to accommodate probe contact with the harder copper surface if test points are not covered with solder during assembly.

Where boards require large grounding surfaces, and the OSP does not coat well or gets washed away, the copper then oxidizes and contact is not acceptable.

3. Postings to IPC TechNet on 13 February 2001 by Robert Furrow (Lucent Technologies) and Darrel Therriault (N-Cube)

One option which gets round these particular problems, although at the expense of more complex processing, is of course to use selective plating, limiting the use of ENIG to test points and ground frames, and protecting pads with an OSP. This prevents any possibility of black pad failures of the solder joints.

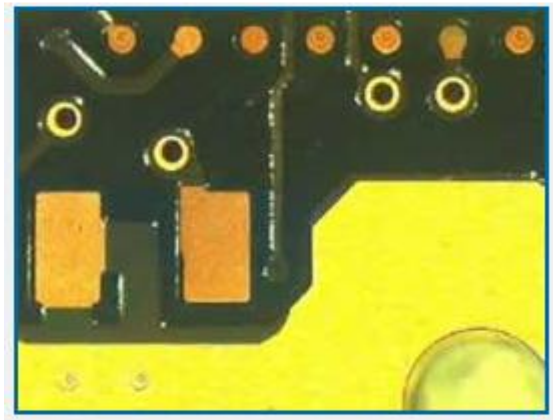

Figure 4: Selective plating: OSP for SMD pads; ENIG for test points and ground frames

Author: Martin Tarr

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