How to measure the conformal coating thickness on your printed circuit board

Dr Lee Hitchens
Nexus

www.conformalcoatinghelp.com
**Introduction**

One of the key challenges in the successful application of conformal coating to a printed circuit board (PCB) is achieving a uniform and consistent coating coverage, at the specified coating thickness.

Too thin a coating will provide inadequate protection against corrosion, or insulation between conductors. If the conformal coating is too thick, it will be prone to coating defects such as bubbles, insufficient curing, and cracking during thermal shock cycles etc.

There are several commonly used methods to measure the applied conformal coating thickness. However, there is currently no reliable, non-destructive method to measure the coating thickness all over an actual coated circuit board.

All the commonly used methods rely either on using a flat control substrate, coated in the same manner as the production part to measure the thickness on a flat panel, or measuring a certain flat area of the circuit board.

The obvious drawback to this method is that you cannot guarantee thickness on sharp edges of difficult to coat devices, which are commonly amongst the most critical areas for preventing corrosion of the assembly in service.

**Destructive conformal coating thickness measurements**

It may be useful to establish a conformal coating thickness baseline for an assembly/process by the creation of ‘golden’ reference boards, using the exact production application method.

This board will then usually be encapsulated in an epoxy molding resin, before being cut and polished. The epoxy resin acts as a 'binder' to keep everything in place.

It is then possible to optically measure the conformal coating thickness at any (or multiple) point chosen.

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The obvious advantage to this method is it enables exact thickness measurements to be made on real assemblies.

The downsides are that it is a destructive, time consuming and labour intensive (read relatively expensive) process, not really suited to production.

So the advantage in this method then lies in performing this at the process set-up stage.

It then enables a statement that say, ‘50 microns on a flat, unencumbered area of the board equates to an approximate thickness of 10 microns on the top of a component lead.

Therefore 50 microns on a flat unencumbered area of board or test sample is the minimum coating thickness we can accept from our process checks, which will be covered next.

**In process conformal coating thickness measurements**

Conformal coating thickness can be measured in either the wet applied state or in the dry, cured condition.

This is for the purpose of providing a process go/no go check, or to create some kind of SPC program during the conformal coating process.

**Wet film thickness measurement**

Wet film thickness measurement of a conformal coating can be used as a process check to ensure the coating thickness is correct prior to drying and/or curing.

In this technique, a simple device, commonly known as a wet-film gauge is used to determine the thickness of applied coating.

The wet-film gauge consists of a series of accurately machined combs, with a differing distance between the marked points and the baseline.

The comb containing markings for the coating thickness required (say 7-12 mils) is placed into the wet coating film and at least one of the teeth should remain coating free.

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If you could see the coating touching the teeth 7-10 mils, but the 11 and 12 mil teeth were free of coating, you would know that the wet-coating thickness was somewhere between 10 and 11 mils thick.

Once completed, the wet film measurement is multiplied by the solids content of the material blend to determine the dry film thickness.

This correlation would usually be performed with one of the dry measurements, to create a go/no go process check.

**Dry film mechanical measurement**

This method is by far and away the lowest cost technique although is limited in accuracy.

The substrate is measured (with calipers) prior to conformal coating, in known and marked locations, usually in a number of places.

The coupons are then coated and processed in the usual production process.

When the conformal coating is dried and is sufficiently hard enough, the thickness is re-measured in the same places,

The readings are then averaged to give an estimate coating thickness with standard deviations being used to assess uniformity.

It is important to know that if the board is coated on both sides, then the thickness measurements must be divided by two, to account for the fact that there are two coating thicknesses being measured.

This is clearly the case with classic vertical dipping, but since it introduces more sources of error, for spray processes it is usual to just coat one side of the panel.
Direct eddy-current measurement

Eddy current measurement techniques are used to measure the thickness of non-conductive coatings on non-ferrous metal substrates.

When the probe is brought near a conductive surface (for example copper inner layers in circuit boards), magnetic eddy currents are created on the surface and can be measured to determine the conformal coating thickness.

Typically, the devices will have options to store measurement results or perform instant analysis of readings and output to a printer or computer for further examination.

The typical tolerance is ±1% within a certain thickness.

Testing is sensitive to surface roughness, curvature, substrate thickness, type of metal substrate and distance from an edge.

The measurement systems need to be zeroed on the substrate being investigated, to subtract the thickness of the non-conductive materials if the measurement is being made on a circuit board.

It is quite usual for a program to use all three of these techniques at various stages of process development and production.

Other alternatives?

Optical measurements show promise for a non-destructive, thickness measurement to take the place of cross-sectioning and dry film measurements.

But, but there are many challenges to overcome, not the least the high reflectance of the solder joints and the conformal coating themselves.

Until this technology has matured, there is still no good alternative to the old tried and tested methods described above.

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