ANSYS Case Study

Manufacturing Audit

A consumer electronics manufacturer was getting 70% yields from one of their factories. They identified a delay between 1 minute and 5 minutes for full power-on of their unit after pressing the power switch, and suspected that a batch of their boards was not conformally coated properly, causing the problem. The company had two factories: one to manufacture surface mound circuit boards and another to assemble the final product.

The company requested that DfR Solutions perform an audit of their manufacturer's processes in both factories to ensure quality.

Approach
First, we performed an audit of factory No. 1. Because the initial suspicion was that the issue was with conformal coating, we first inspected materials used, followed by their application and cure cycle. Then we observed assembly in factory No. 2 to determine if the process was hindering product reliability.

Conformal Coating
Conformal coating is applied to circuit cards to provide a dielectric layer on an electronic board. This layer functions as a membrane between the board and moisture in the environment. With this coating in place, the circuit card can withstand more moisture by increasing the surface resistance or surface insulation resistance (SIR). With a higher SIR board, the risk of problems such as cross talk, electrical leakage, intermittent signal losses and shorting is reduced.

The reduction in moisture provided by a higher SIR board will help to reduce metallic growth of dendrites and corrosion or oxidation. Conformal coating will also serve to shield a circuit card from dust, dirt and pollutants that can carry moisture and may be acidic or alkaline.

Conformal Coating Materials
There are several types of conformal coating materials; the selection of one for the application must consider several variables.

	PROPERTIES	COMMENTS
Epoxy	Good adhesion Excellent chemical resistance Acceptable moisture barrier	Difficult to rework Needs compliant buffer Not widely used
Urethane	Good adhesion High chemical resistance Acceptable moisture barrier	Difficult to rework Widely used Low cost
Acrylic	Acceptable adhesion Poor chemical resistance High moisture resistance	Easy to rework Widely used Moderate cost
Silicone	Poor adhesion Low chemical resistance Excellent moisture resistance	Possibility of rework Moderate usage High Cost
Paralyne	Excellent adhesion Excellent chemical resistance Excellent moisture resistance	Impossible to rework Rarely used Extremely high cost

Acrylic conformal coatings are perhaps the most popular of all conformal coating materials due to their ease of application and removal and their forgiving nature. Acrylics dry rapidly, reaching optimum physical properties in minutes, are fungus resistant and provide long pot life. Additionally, acrylics give off little or no heat during cure, eliminating potential damage to heat-sensitive components. They do not shrink during cure, have good humidity resistance and exhibit low glass transition temperatures. The material also has a continuous operation range of -65 C to +125 C.

The PCB manufacturer was using red adhesive acrylic as a coating material, which when cured should be very hard.

Coating Process
The coating process worked as follows. The top side was spot coated. The bottom side was coated and inspected under UV light. The measured thickness of the coating was 70-100 µm.

As a side note, we also identified hand brushing flux residue as potentially hindering the manufacturing process. The manufacturer was hand brushing trichloroethylene (TCE, chemical formula C2HCL3), which is a well-known environmental and health hazard. TCE is mostly prohibited in the United States and if it came out that their supply chain was exposing their workers to TCE, there could be a huge blowback (spike in rate of cancer in workers, killing of wildlife, etc.). The fact that the manufacturer was using it with a brush, with full exposure to workers, was an even bigger concern.

Additionally, the use of a brush and TCE on the no-clean ROM1 was also concerning from a reliability perspective. The only way a ROM1 would be no-clean would be with heavy rosin encapsulation. If they brushed clean, they were disrupting that encapsulation system and greatly increasing the risk of dendritic growth or drops in insulation resistance.

Curing
Curing methods include air, UV, thermal and moisture laden atmospheres. Time to cure is a function of the type of coating and the application method.

The conformal coat data sheet defined the cure cycle to be either 24 hours at room temperature or 2 hours at 76 C. However, our audit identified the actual conformal coat cure cycle to be 4 +/- 1 minutes at 70 C. This means that the boards were not completely cured when they came out of the oven, leaving them open to contamination from handling or moisture penetration from high humidity. With the transition to system integration occurring almost immediately at factory No. 2, the potential for contamination due to handling was increased.

The manufacturer assumed that the coating continued to cure further once taken out of their facility. Unfortunately, that's not what was happening. The second facility was taking them straight to the manufacturing floor.

Inspection on Facility No. 2
The units from factory No. 1 were shipped to the integration company across town right away and were tacky due to the incorrect time for curing. The integration facility was not air conditioned, and with humidity levels at 90% this coating did not continue to cure. Workers at facility No. 2 were required to wear gloves when handling units. But due to tackiness, the gloves were sticking to the coating. To avoid sticking to the materials, the workers cut the fingers off their cotton gloves so that they would not stick to the conformal coating. This resulted in oils from their hands getting on a crystal, causing failure at test (70% yield).

Key recommendations
Our two main recommendations were:
- Change the cure cycle in facility No. 1 to comply with the data sheet requirements.
- Change the gloves in facility No. 2

Result
After manufacturers implemented these two recommendations, the yields increased to >90% compared to 70% before the manufacturing audit.

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