IMPROVED RELIABILITY PERFORMANCE OF JET DISPENSABLE POLYMERIC COATING MATERIAL

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ABSTRACT
OSCA materials are dispensable or printable polymeric coating material, which is One Step Chip Attach Coating material designed to form a protective layer around solder joints, which ultimately results into results into reduced corrosion, salt formation, and dendrite growth. Advantages to using this material includes no masking that reduces process time and cost. The material is designed to have controlled flow after dispense, fast cure and simpler process compared to standard conformal coating. It can be dispensed using Jet or Auger technologies, which integrates into existing assembly equipment. There is no need to coat entire device. Device can be selectively coated on most critical areas or areas known to be susceptible to corrosion. After dispensing, this material can be cured in convection oven and can be cured in few minutes between 140-160°C**.** This paper presents reliability study of highly corrosive printed paste with polymeric coating material and comparing it with conformal coating.

The study was designed to compare a paste that barely passes SIR at 85C/85RH with polymeric coating material, Silicone conformal coating, and acrylic conformal coating. Another part of this study was to study thickness effect on reliability results. Preliminary results show formation of tin salts around traces and some corrosion on uncoated areas, but it was not observed after polymeric coating material was printed on the board. Using this new material as coating prevents formation of salts, corrosion and dendrite growth. Material thickness and volume of material dispensed on the area is very important to obtain optimum results with this polymeric coating material.

Key words: Polymer, Selective Coating, Reliability, Epoxy coating

INTRODUCTION
Typical failures in electronics industry caused by current leakage, which is caused by reduction in surface insulation resistance (SIR) between conductors. [2] Formation of conductive metal filaments also known as dendrites causes current leakage and ultimately results into poor reliability results. Dendrites migrates usually forms on the surface of PCB and leakage in current will continue to increase once dendrites have been formed. Tin salt formation can also be observed during SIR testing, which will also result into reduced current. An example of dendrite salt formation is shown below in fig. 1.

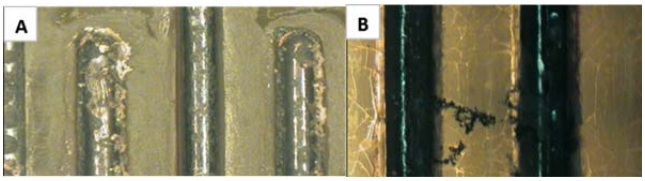

Figure 1: Formation of (A) Tin salts (B) Dendrites

Epoxy resin based materials have been used in the electronics industry as conformal coatings, adhesives, encapsulants, and laminates. [1] Epoxy materials have been used as protective layer in various applications. It provides good chemical and electrical properties. Acts as barrier between solder and humidity, which turns into higher reliability compared to without coating. Materials tends to have long room temperature stability, good thermal resistance and no change in color upon aging. High resistance to organic solvents, moisture and salt spray provides excellent reliability results even at elevated temperatures. They are also abrasion resistant and tough, which can be used into harsh environments. [1]

One Step Chip Attach (OSCA) materials designed to provide high throughput, less processing steps, which results into reduce processing time. It also eliminates lengthy cleaning and drying step. OSCA-C material is family of polymeric materials designed to provide protective coating layer on specific area of PCB. It provides protection from harsh environment to specific area of PCB. Process steps are minimized with no requirement to mask and no drying required. The process for using this material doesn't require additional assembly equipment. This material can be stencil printed, jet dispensed or auger dispensed. It only requires two steps after a package have been placed on PCB. Step one is dispense at specific volume of material to specific location and next cure in the oven at specific temperature.

EXPERIMENT
The solder paste A used for this experiment is known to form dendrites and salt formation. It barely passes IPC standards reliability requirements. Solder Paste B does have high reliability performance. Solder paste A and B are both no clean VOC-free products. Table 1 below shows reliability test standards.

Table 1. Custom Reliability Test Standard used

Test Method	TM 650 2.6.3.3
Temp (^{o}C)	85
Humidity (%RH)	85
Test Voltage (V)	-100
Bias Voltage (V)	50
Test Duration	168 hours
Test Frequency	Every 20 minutes
Board Character	IPC B24
	0.4 mm lines
	0.5 mm spacing
Pass Criteria	IR > 10^{8}

Aerosol based acrylic and silicone conformal coating were used to compared with OSCA-C (epoxy based) coating. The experiment was designed to test various different materials and compared against reference. Conformal coatings were applied as directed by supplier. Test matrix can be found in table 2 below.

Table 2. Test Matrix for Different Types of Coating

#	**Type Coating on PCB**
1	Bare Board
2	Solder Paste A
3	Solder Paste B
4	Bare w/ thick OSCA-C coating
5	Bare w/ thin OSCA-C coating
6	Paste A w/ thick OSCA-C coating
7	Paste A w/ thin OSCA-C coating
8	Paste A w/ Silicone Conformal Coating
9	Paste A w/ Acrylic Conformal Coating

RESULTS AND DISCUSSION

A. Chemistry and Rheology Considerations

Previous studies have shown that activator package used in solder paste greatly influence reliability performance. [4] Stronger activators reacts with metal oxide and forms metal salts. Solder paste A contains significantly higher activator conductivity compared to solder paste B. Therefore, paste B results into much better reliability results.

OSCA-C is applied on solder solder paste and cured at 150C for 15 minutes to form protective layer. The material must have controlled flow to be able to dispense at specific location without going into no go zone. OSCA-C material must exhibit enough rheological properties. With few percent of rheology modifier, material flow can be controlled. Even at high temperature during cure, material is designed to have minimal flow. Fig.4 presents viscosity and yield stress response of OSCA-C material. Material contains enough yield stress, which resists capillary forces from substrate after dispense and maintains material at dispense location. [3]

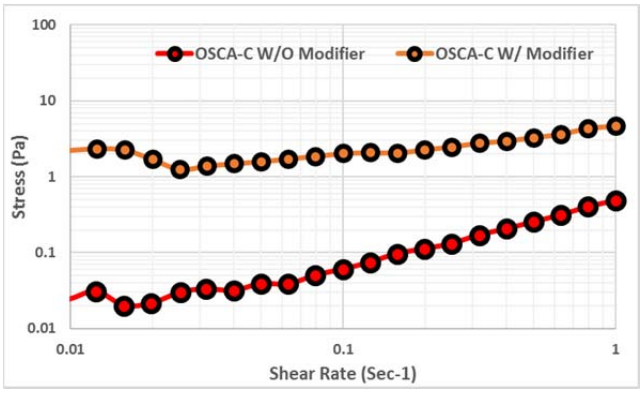

Figure 2: OSCA-C Stress vs Shear Rate response with and without rheology modifier

B. Reliability Test

Reflow profile used to reflow solder paste is shown below in fig. 4. SIR test results from IPC 2.6.3.3 are shown in fig. 5 for solder paste without coating and comparing paste A vs B. As expected, solder paste A barely passes reliability with resistivity value close to 10^{8} Ω and solder paste B has resistivity value around 10^{11} Ω. As explained previously, paste A presents higher ionic conductivity than paste B. [4] Dendrites and tin salt formation was observed for paste A and not for paste B. Studies have shown that Sn^{2+} in paste A either forms less soluble or oxidizes into Sn^{4+} and precipitates out. [4] Current leakage or low resistivity is caused due to tin ions from cathode to anode. Paste A was picked for further evaluation because we were looking for worst possible condition.

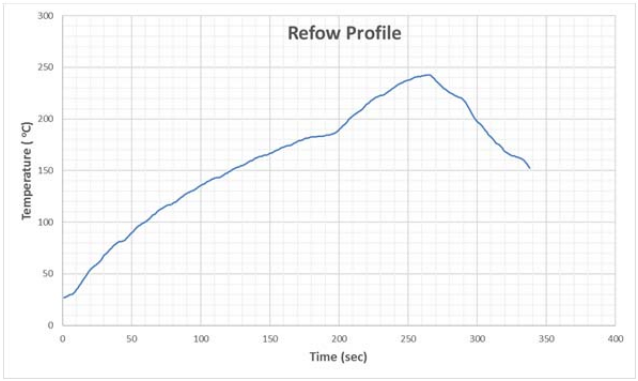

Figure 3: Delphi 1 reflow profile

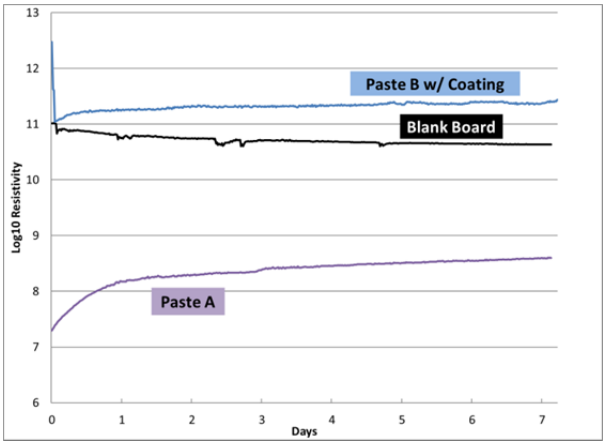

Figure 4: SIR results Plot

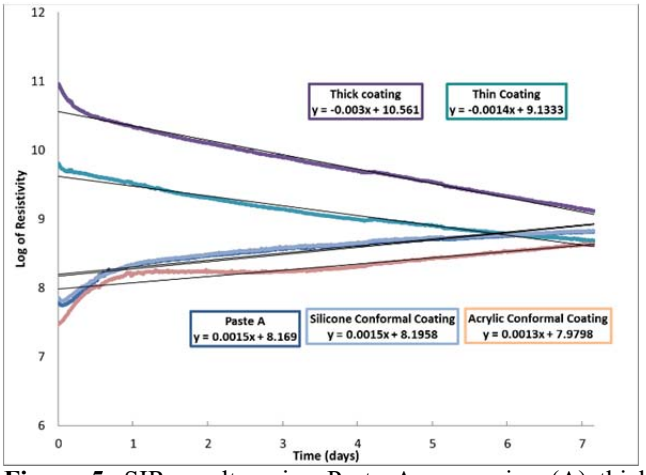

Figure 5: SIR results using Paste A comparing (A) thick OSCA-C coating (B) thin OSCA-C coating (C) Paste A (D) Silicone Conformal Coating (E) Acrylic Conformal Coating

Dendrite and salt formation can be avoided by stencil printing or jet dispensing OSCA-C material on B24 board. Thickness of coating shows slight difference in resistance, but no sign of dendrite or salt formation was observed after coating. SIR results from IPC 2.6.3.3 are shown in fig. 6 using paste A with OSCA-C, acrylic conformal coating, and silicone conformal coating. The results clearly show improved resistivity values by applying OSCA-C. Acrylic or Silicone based conformal coating either had similar results or minimal improvements compared to paste A without coating. Table 3 below shows resistivity values at day 1, 4 and 7. Effect of having coating on paste A can be clearly seen in the raw data. The rate at which moisture passes thru coating is much slower, which results into improved resistivity performance. No dendrite or salt formation was observed on coated materials, but the resistivity value keep decreasing. It could potentially be due to strong ionic residues that reacts rapidly with high level of moisture.

Table 3: Log10 resistivity values with various different conditions at days 1,4 and 7

#	Type Coating on PCB	Log RI after 1 day	Log RI after 4 days	Log RI after 7 days
1	Bare Board	10.82	10.67	10.61
2	Paste A	8.18	8.65	8.82
3	Paste B	11.24	11.33	11.40
4	Bare w/ thick OSCA-C coating	10.06	10.03	10.01
5	Bare w/ thin OSCA-C coating	9.48	9.57	9.83
6	Paste A w/ thick OSCA-C coating	10.33	9.67	9.12
7	Paste A w/ thin OSCA-C coating	9.54	8.98	8.70
8	Paste A w/ Silicone Conformal Coating	8.34	8.65	8.82
9	Paste A w/ Acrylic Conformal Coating	8.17	8.30	8.63

CONCLUSION

OSCA-C materials are designed to be dispensable specific coating material. Advantages to using this material includes faster processing times, fast curing, and no drying step. There is no masking required and minimal volume of material will be required, which end up reducing cost and much faster processing. This study shows that reliability performance can improved using this material. Paste A performed poorly with dendrites and salt formation, but with OSCA-C material it wasn't observed. Using acrylic or silicone conformal coating showed negligible resistivity improvements.

NEXT STEPS

More testing must be done to complete the evaluation. Paste B was not evaluated with coating, which much be done to complete testing and compare results with paste A. Can reliability performance be improved using OSCA-C coating?

ACKNOWLEDGEMENTS

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