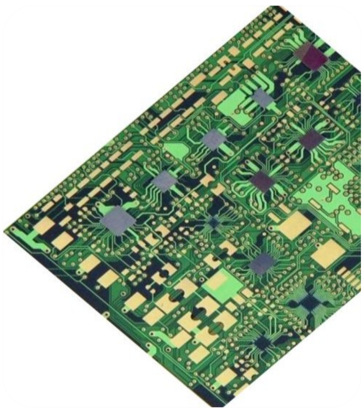
CE

Selective Conformal Coating
& Focused Heat Cure

● BUBBLE-FREE & ENERGY SAVING
COATING SOLUTION: PAT. 0550606

January 31, 2018



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Selective, Conformal Coating
and Focused Heat Cure

Introduction

Conformal Coatings, of all types, serve a very useful purpose of circuit protection in harsh environments. They can modify the Surface Insulation Resistance and provide a barrier to chemical or moisture attack. They can assist with mechanical shock resistance and help to keep dendritic growth down to acceptable levels. They will never stop dendrites, nor Tin Whiskers, from growing in the first place, but they will limit their activity and reduce the incidence of cross-talk or short circuits.

There are many applications where Conformal Coatings have become the norm because of this protective property, BUT, it has to be said that Conformal Coating introduces further steps into the process chain and every step in that chain carries a risk of error – even though that error might be infinitesimally small. The basic SMT process of Print Solder Paste / Place Components / Reflow Solder is a three-stage process and there are therefore three areas of error risk.

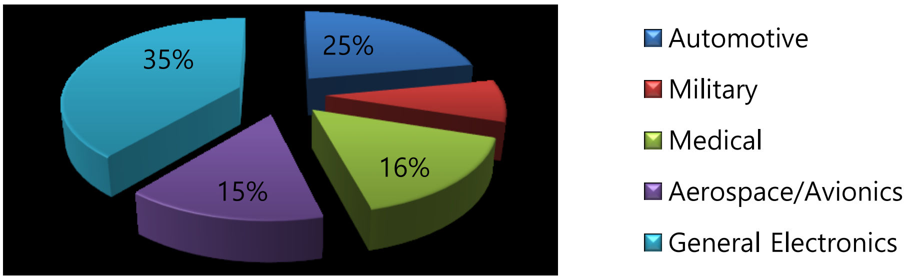
So, what is an error? The old perceived wisdom suggested that it is anything to do with a defect in the production process. Things like DPMO (defects per million opportunities) definitely apply but, we should also consider things like efficiency levels. After all, we are supposed to be “lean, mean and hungry” and we use concepts such as Lean Manufacturing regularly. This is where Selective Conformal Coating starts to make an impact. It is an efficient process.

There is no hard-and-fast rule that states that material A is the only coating material for a particular task. All coatings perform to the protective requirements mentioned above. So, for example, a Silicone material is a rubbery compound that has a fair degree of flexibility whilst adhering fast to the surface. It is therefore used extensively in industries where flexibility is required such as flex circuits or flex-rigids. The downside is that Silicone is very difficult to clean and equipment needs regular cleaning and maintenance. There may not be any errors in the product but the efficiency of using Silicone may affect the overall factory efficiency. Other materials may need specific processes and so the choice of material boils down to protective requirements plus ease of use.

Broadly, there are 6 material types that are commonly used: Acrylics, Polyurethanes, Epoxies, Silicones, Parylenes and ARUR - which is a mix of Acrylic and Polyurethane. It is not the purpose of this article to discuss these materials in detail. They all have characteristics with respect to ease of use, rework, protection, industry usage, and so on. Nor with this article be a guide to which is the best material for any application. The main purpose here is to discuss Selective Conformal Coating which is suitable for all of these materials, with the exception of Parylene which requires has a vacuum deposition process, not a spray process.

If the product and the end-use demand it, any industry can adopt Conformal Coating but certain industries have historically used coating techniques for a long time. These are typically Aerospace/Avionics, Automotive, Military and Medical. The Medical Industry is the least prone to change because of the regulatory procedures that must be undertaken, but the other industries, and any others, tend to choose a material for a particular purpose and then only change if necessary.

Conformal Coatings in 2015



▲Typical, Industry Take-Up of Conformal Coating

From a production point of view, we must consider the technologies available to provide the production efficiencies we require. There are factors such as: volumes or throughput, cleaning and maintenance, masks, flexibility of use, tooling, and repeatability that must be considered. We also need to consider costs, quality issues and special requirements such as the vacuum system demanded by Parylene.

Focused, Heat Cure

There are essentially four types of curing techniques, depending on the chosen material. Heat Cure, UV Cure, Moisture as a catalyst cure and vacuum deposition. Most materials use either heat or UV and there are a number of solutions available to provide the required throughput. Materials that require moisture as a cure catalyst will require extra cost to provide the moisture control. Vacuum deposition systems (Parylene) will be very expensive and are only available as is a batch process which means that throughput depend on the coating amount and the batch sizes. Parylene is widely used by the Military and Aerospace industries because it coats very thin layers all over the product – even underneath components and batch sizes tend to be small.

UV curing can either be a dwell process or a constant-movement in-line process. A dwell process means that the product dwells on a conveyor under a UV source for whatever time period the material needs. Throughput depends on the cure rate per product. An in-line UV cure system has a controllable conveyor with a UV radiation system along its length so that boards are passed into it from a coating system on a regular basis. The length of this oven dictates the throughput. UV curing does NOT suit magazine batch curing since the UV must “see” all of the conformal coat material on the board in order to cure it. Consequently UV systems need to process one board at a time.

Heat Curing, as its name suggests, requires the application of heat to polymerize the material to cure the coating. In-line reflow ovens, situated after the coating system, can be set up for a cure profile and are often used for this application. There is a unique alternative to conventional in-line heating and this is a magazine based system with a cyclic-run-conveyor. This technique is a TTnS patented invention for curing and can offer advantages over conventional in-line heat curing because the floor area is usually much smaller and, more importantly, the need to load a magazine with product before the magazine transfers into the batch oven means that the product undergoes “relaxation” time before heating. During this relaxation time, solvents (either aqueous or alcohol based) will start to evaporate naturally before higher temperature curing takes place.

This relaxation time is extremely important from a quality perspective because this time period yields a reduced propensity for voids and/or bubbles to occur in the material. A typical in-line reflow system probably will generally not have sufficient relaxation time for most of the solvent to evaporate. Therefore, the probability of voids or bubbles in the coating using in-line reflow system will be much higher than using a Magazine based system. Voids and bubbles are a significant quality issue because they could lead to poor adhesion, they could yield a site for dendritic growth to begin, and they also reduce the dielectric properties of the board.

▲ECO99C

▲ECO120C

ECO99C (ECO120C): TTnS, Focused Heat Curing Oven. The batch magazine system above has a floor area of 2.4m(3.0m) long x 1.2m wide, excluding input or output magazine loaders. It can heat 3 magazines' worth of product at one time and will be often faster than an in-line system in a much smaller floor space. PAT. 0550606

Material Application

There are essentially four processes used to apply conformal coatings: Manual. Semi-Automatic, Fully Automatic and Selective Automatic. These are volume and reliability driven. If the volumes are small and the repeatability obtained from manual application is within tolerance limits, a manual paint, dip or spray system can be used. Very often, this technique is used with a material that cures in ambient atmospheres and temperatures. So, the human operator who applies the coating usually also lays out the product on a bench to cure naturally overtime. This method will not often show any signs of voiding but can only be used with very low volumes. It may also be a method used where coatings have to be applied under an object that is already fitted to the board such as a high-voltage connector.

Semi-automatic systems also require some form of human capability, usually by an operator holding a spray gun in a cabinet. Volumes are larger than for purely manual systems and often the cabinet has some form of fume extraction so that unwanted vapors can be exhausted. Semi-automatic systems therefore have some impact on floor space. Fully automatic systems only require human intervention from the production engineering point of view and should be relatively self-running after programming. However these machines tend to be inflexible and coat the whole board so that essential. Unfortunately, masking can be a significant undertaking, often requiring many hours of manual labors.

Selective automatic systems were developed to avoid the restrictions of purely automatic systems. Particularly, with respect to the reduction, or elimination, of masking... These systems are fully programmable, computer-driven, and make use of multi-axis heads to apply coatings only where they are needed. Masking is rare because the selective programming allows “keep-out” zones to be set up so that parts like connectors can be left uncoated, as required. Film coat heads together with the multiple axes head systems yield a very precise material amount, sprayed very accurately, and at a speed that will keep up with many high-speed assembly systems. A tact time of 30 seconds or less for an A4 panel size is common and so the beat rate of the production facility can be met. The selectivity and programmability of the machines mean that material usage is optimized and human intervention is minimal or zero (except for maintenance activities).

Film coating heads can handle very low viscosity material applications. They will be able to handle viscosities between 10 and 100 cps and apply films at between 0.0125 and 0.125mm thickness. Spiral spray heads will offer more viscous materials to be handled, typically up to 3000cps and they can offer thin films of below 0.1mm if required. Even some masking activities can be automated for some applications although it is better to use the power of selection to yield the optimum performance.

▲TCM45A_XL / Six(6)-Axis ROBOT
Full-Auto, UV Curable Coating WorkCell

▲TCM45A / Five(5)-Axis ROBOT
Full-Auto, Coating WorkCell

TCM45A_XL(TCM45A): A typical TTnS’s Selective Coating ROBOT. It is a full 5-axis(6-axis), fully programmable system

There has been a long-running debate about cleaning circuit boards prior to coating. On the one hand, using coatings to “seal in” fluxes or objects like solder balls seems to be a practical way of restricting their activities. On the other hand, if they are on the board in the first place, they could lead to dendritic growth or electronic damage underneath the coating. The consensus of opinion building up today is that it is better to clean the surface fully after assembly so that there is no risk of any unwanted objects remaining on the board. It is also likely that cleaning the board will also provide some degree of surface preparation so the coating is more likely to adhere readily to the surface.

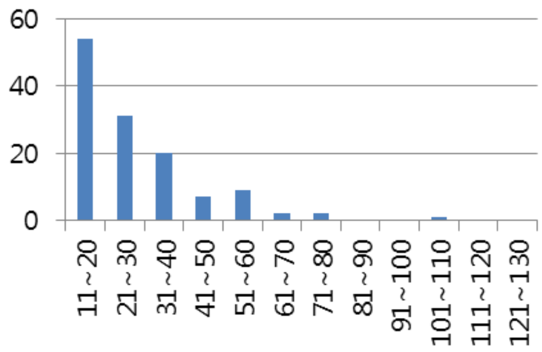
If peelable masks are used at all, there will be an operator involvement to apply them and then remove them after coating. The alternative is to use solid masks which could be metallic or plastic covers or frames. Either way, there is a cost implication. Labor for peelable masks and some form of cleaning system for solid masks.

Some of the quality control issues that are part of the conformal coating procedure can be alleviated by using selective coating. Selective systems give very precise and consistent coatings. In the electronics industry today, QA procedures are increasingly demanding repeatability. Any manual tasks will inevitably affect repeatability. Voids are almost inevitable but the right choice of selective coater and curing system will reduce them to insignificance or eliminate them altogether. There should, of course, be a zero contamination risk and so pre-cleaning is becoming more important. It is likely that SIR tests will be carried out to determine the level of contaminants.

Tin Whiskers

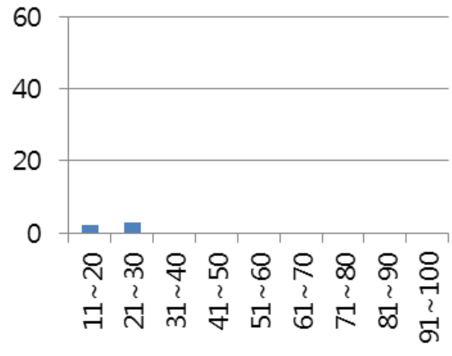
The RoHS legislation has meant that there has been an upsurge in the use of tin plating on circuit boards and components because of the banning of lead. Tin has a propensity to create whiskers. A lot of work has been done to establish if conformal coating alleviates or helps to control Tin Whiskers and much of this work has already been published. Cleaned and coated circuit boards are more likely to inhibit whisker growth than unclean, non-coated boards as shown in the charts below. One set of boards was cleaned in alcohol in an ultra-sonic bath whilst another set of identical boards was left "as-assembled". Although Tin Whiskers occurred on the coated boards their existence was small and controlled.

▼Non-Coated PCB's



Whisker length (μm)

▼Coated PCB's



Whisker length (μm)

The coated PCB had only 5 Whiskers and the longest was 30μm. The non-coated PCB had over 100 whiskers and the longest was 104μm. So, although coating does not prevent whiskers from occurring, it reduces their influence considerably. Flux residues and moisture are major contributors to Tin Whiskering and conformal coating allows a good degree of control over these factors.

Conclusion

There is no hard and fast rule that dictates whether one should conformally coat or not. Some industries demand that coating takes place, some prefer to “play safe” and clean then coat and some follow the crowd because it seems a sensible thing to do. Coating without actually knowing all the “ins and outs” is a mistake and it is gratifying to note that very few users coat products without having good cause to do so.