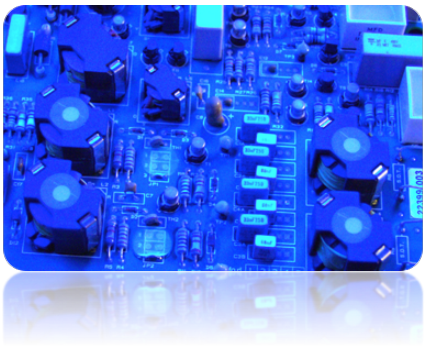
Technical Bulletin

How to Select a Conformal Coating Material

Choosing a conformal coating material is a complicated and involved process usually balancing a number of trade-offs and compromises. This is because there is no such thing as a universally applicable conformal coating. The aim of this article is to give you an idea of the questions to ask yourself and your suppliers to shortlist suitable materials for the end application.



Factors to Consider

When selecting a conformal coating you are going to need to consider several factors which if you are lucky will all add up to at least one material choice. If not, then compromises are required.

Factors to be considered are:

- Temperature Operating Range
- International, Customer or National Standards
- Environmental Considerations
- Chemical Resistance
- Requirement to Rework the Conformal Coating
- Application Process Considerations
- Curing the conformal coating
- National, State, Regional Legislation and Insurance
- Supplier Performance
- Price

Each of these factors is examined briefly to allow an insight into the complexity of selecting a conformal coating material.

SCH Technologies is a Trading Name of SCH Services Limited
Newburgh Building, McLintock Way, Barnsley, South Yorkshire. S70 6BF
Tel: +44 (0)1226 297711 Fax: +44 (0)1226 297733
www.conformalcoating.co.uk

Temperature Operating Range

Conformal-coated assemblies will often be exposed to a wide range of operating temperatures during their service life. It is important to understand the maximum and minimum temperatures that the unit will be exposed to. This needs to a holistic and realistic appraisal.

For example, if your boards are operating in an unheated part of an aircraft, they could easily see -65ºC when airborne. When on the runway, they could easily see +100ºC. Then you need to consider the heating effects of the circuit, certain local hot spots on the assembly could reach local maximums of 125ºC say. Then your operating range becomes -65 to + 125ºC.

If your operating range goes below -65ºC or above 150ºC then your choice is made simple, because silicone conformal coatings are the only materials that will survive extended use at this range. If your operating range is within this window, then keep reading.

International, Customer or National Standards

The next question to ask is whether your customer or end application requires the conformal coating to be qualified or approved to international, national or customer specific standards.

Examples of these would be UL746E (Which includes UL94) North American Safety Standard, MIL-I-46058C, or BMW GS95011-5. The Qualified Product Lists (QPL) will significantly reduce the number of coatings available to you. The Specifications such as the IPC-CC-830 Standard does not have a qualified product list. However, any product that appears on the MIL-I-46058C QPL, is automatically said to meet the requirements of IPC-CC-830. There are a lot of materials that state that they 'meet the requirements of IPC-CC-830'. Any material making this claim that does not appear on the MIL QPL must have a publicly available test report to backup these assertions. You will need to see this report in order to keep a material in your shortlist.

Environmental Considerations

A conformal-coated printed circuit board can be exposed to many different types of deleterious environments. For any unit that will be placed in a partially sealed protective housing, the conformal coating would be considered secondary protection only and therefore likely to be subjected only to condensation and humidity as the temperature within the housing changes. Acrylic materials are widely used in such applications, although silicone materials generally offer the best protection in condensing environments. The following describes the most commonly encountered environmental conditions that may need to be met:

High Humidity

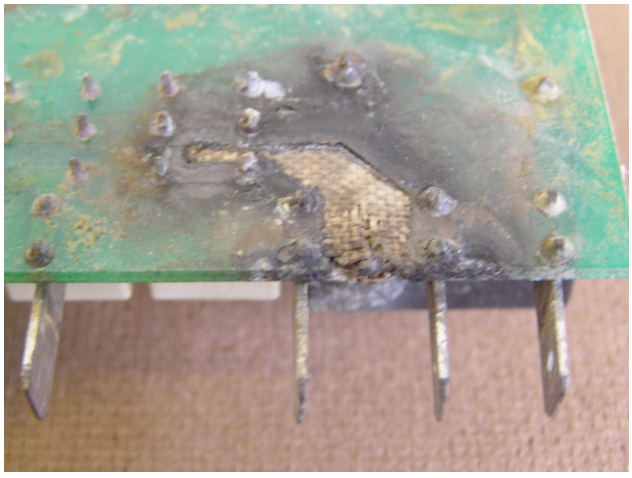
When high humidity is the issue, Silicone Materials can be an order of magnitude more porous to water vapour than other coating chemistries. Acrylics and Urethane chemistries all have good resistance to high humidity environments. Two-component (two-part) materials and materials that chemically cross-link to a significant degree would all be expected to provide a better barrier to humidity.

Salt-Spray Environments

This is a very common requirement in many customer specifications, but not within any of the common general specifications. The key to success with Salt Spray environments are even and uniform, void-free coverage of the assembly. Chemically, salt-water is benign to most coatings. However, the tests and the environments will test workmanship and find defects in the applied coating. Silicone materials and urethane chemistries are often used in these applications, although acrylics can pass most test regimes.

Corrosive gases

These environments are perhaps the toughest of all, since the corrosive gases will expose any defects or voids in the applied coating. In addition, there is a real differentiation between coating chemistries in protective capability. Acrylics and single-component alkyd, or urethane chemistries are all extremely susceptible to corrosive gases. Two-part polyurethane and epoxy chemistry mostly show good resistance, but some single component UV curable materials and single component silicone chemistries provide very good resistance too. UV curable materials are significantly cross-linked and so this is not surprising. Silicone materials seem to work by reacting to form chemical bonds with the metal surfaces which largely inert the metal substrate from corrosion.



Corroded PCB not protected by conformal coating

Immersion Environments

When the assembly is likely to be immersed in water, there is only one real choice, and that is to use Parylene, a vapour deposited conformal coating that provides exceptional coverage and insulation. Liquid applied silicone coatings can provide decent protection if applied at a generous thickness.

However, the key is quality workmanship and process quality control since immersion will find any weak areas of coverage.

For immersion-in or splash by solvents, the results are very dependent upon the particular coating chemistry and solvent of interest. In general, two-part materials would be the best choice, although some UV curable materials provide outstanding chemical resistance.

Requirement to Rework the Conformal Coating

It is possible to rework most types of conformal coating if necessary, although some conformal coatings can be very difficult to rework. If your assembly has a long service life, will be placed in a housing and be subjected to multiple upgrades and repairs over its life (common in military and aerospace applications) then acrylics are without a doubt the easiest type of coating chemistry to remove and rework, due to their very limited chemical resistance. Single part acrylic, urethane and alkyd materials can be removed by chemical methods in machines like a conformal coating wet stripping system.

Stripping Conformal Coating from a PCB

Any two-part chemistry, Silicones, Parylene's and UV curable materials are best removed locally by media blasting with an ESD safe media blaster. Provided the coating is less hard than the solder mask, then a good degree of selectivity can be achieved with this method, which will be covered in a forthcoming 'How To' guide.

Application Process Considerations

With enough engineering expertise and budget, any material can be made to work in any type of application method, with the exception of Parylene, which can only be applied by vapour deposition in a dedicated application system.

However, there are certain combinations that lead to extreme process difficulty and / or cost implications and are worth considering:

Solvent-Based materials

All single component solvent-based materials, with the exception of some moisture cure urethane chemistries can be successfully applied by any of the common techniques. Two-part solvent based

materials work best with spray or brush applications and can be applied through robotic applications with the right system specification. Unless you are willing to throw away a dip tank of material when the pot-life is exceeded then dipping is far from ideal.

UV curable materials

UV cure conformal coatings are ideally designed for high volume, high throughput environments and are best applied by selective coating equipment with an immediate in-line, conveyorised cure operation. However, due to their outstanding protective properties, they find application in low volume applications too. In this case, manual spray coating is acceptable, as long as the coating thickness and cure process are carefully controlled to ensure the thickness is within specification and to avoid over-cure. Also, when curing UV materials and masking is involved, consideration must be given to this.

Water-based materials

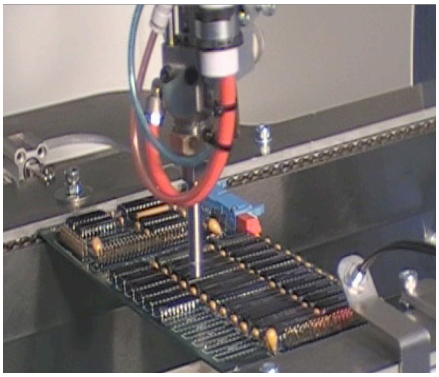
Work best in a manual application process, be it dip, spray or brush. Water-based materials are difficult to apply with repeatability and reproducibility with selective spray equipment, and can be impossible to cure in an in-line process due to the excessive thickness of material applied in these methods.

Silicone based materials

RTV silicones are not really suitable for dip coating applications without inert gas systems in place, but heat-cure silicone materials are ideal. With this exception, silicone chemistry can be successfully applied by any methodology.

Selective Robotic Coating

Nearly all of the robotic manufacturers make equipment can apply conformal coatings successfully if correct specified. The key is to understand the valve technologies and how that relates to the material, the quality of the spray process and the speed of processing. For instance, when considering switching from a solvent based coating using a non-atomised valve to an environmentally friendly coating such as a UV cure or silicone cure product then it should be realised that a change of valve technology is probably needed and there will be speed limitations, and therefore throughput penalties.



Robotic System applying conformal coating

Dipping

Generally, all conformal coatings can be dipped in a dip coating system. However, a wise rule of thumb is to avoid dip-coating methods for any material containing a moisture-cure mechanism unless you wish

to add in expensive process controls such as inert gas systems. Also, although perfectly possible to dip UV cure coatings it is critical that the system is designed to do this with particular safeguards in place.

Hand Spraying

All conformal coatings can be hand sprayed within a spray booth and the process of consideration is the same as for the robots. The easiest are the single part coatings. Two part coatings will have a shelf life to consider and products such as UV cure and moisture cure will need to be handled carefully.

If you are constrained by existing capital equipment then your choices may be more limited, but if new equipment can be purchased, then there are far more choices.

Curing the conformal coating

When talking about cure times, there are several definitions to be aware of:

1. Drying Time to handle. This is the time at room temperature at which the coating is dry to the touch and can be handled or moved onto another operation.
2. Time to full cure. This is the time until any physical drying process has been completed and any cross-linking reaction has taken place. Elevated temperatures or other methods of catalysis can usually reduce the time to full cure.
3. Time to optimum properties. Intuition would tell you would think this would be the same as time to full cure. However, even when the coating is fully cured, other properties such as adhesion can develop over time

From a production flow point of view, it is desirable to minimize the time to handle and time to full cure as much as possible, taking into account the factors previously discussed. From a lean production point of view, minimising the time to optimum properties enables you to ship product you know is at its optimum, or enables these properties to develop during transport time to the end customer, without having to store a significant number of days of inventory.

National, State, Regional Legislation and Insurance

Most countries, states and even regions have their own legislation relating to the emission of Volatile Organic Compounds (VOCs), with differing definitions and interpretations. When installing a new process you need to be mindful of these, and if possible, use a compliant material. For existing processes, there are options including carbon filtration, solvent collection, or oxidising (afterburner) units that can be installed at significant expense, although this can be more effective than re-qualifying

new materials with multiple end customers. Sometimes, process and / or performance considerations will require this type of solution, even for new qualifications.

Shipping flammable, hazardous materials is expensive and requires a specialised freight firm in most countries. Using a safer material can simplify logistics and reduce cost. Using flammable, hazardous materials is inherently more dangerous with a greater risk of serious injury, long-term exposure effects or catastrophic incidents, and this is reflected in insurance premiums, which is another opportunity to save cost. Sometimes, incidents within plants, such as fires will necessitate a change in material, regardless of process, lack of business case or any other driver, other than compliance.

Supplier Performance

Choosing a conformal coating material is a long and exhaustive process, with many considerations and conflicting choices and tradeoffs to be made. Most suppliers would walk you through a similar framework to this to decide on the most suitable conformal coating for consideration on your shortlist.

This consultation provides a valuable insight into your potential material supplier. If they are unwilling or unable to help you through the selection process, then they are unlikely to be much help to you with any ongoing issues that need to be resolved. If you get great support and back-up prior to qualification, then this is an indicator that your supplier knows your business well enough to become a value-added supplier during production.

The sampling process will help you understand the geographic reach of your potential supplier, and local availability etc. If your sample has to ship halfway across the world, then your supply chain is likely to be unsuitable or difficult in production.

Finally, a key factor is quality control of the manufacturing process. Consider the costs for withdrawing a product that has been coated in a conformal coating that has been produced incorrectly. Traceability and quality control of the process is critical to avoid a disaster at a later point.

Price

Many materials are selected on price. Although this is a valid point, consideration of all the other factors is arguably as important if not more. Ultimately, the cost of the coating is fractions of the true of manufacture and the wrong material specified at the design stage can cost many times the saving originally considered.

Conclusions

Selecting a Conformal Coating is a crucial stage of the design process. However, it should be considered in the context of all the factors outlined above. If not, then it should not be a surprise to find problems later down the process stream that could have been avoided from the start.

If in doubt, check with the supplier and independent experts. Do not neglect this stage or your process and final product could be compromised.

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