Conformal coating clarified

Conformal coating is used primarily to protect PCBs from environmental contamination and damage, but it can also have other beneficial effects. However it is a tricky process to automate and control – especially if the boards are awkwardly shaped and volumes are low – and there are also several different types of coating available. Chiltern Connection's Peter Woollcott discusses the merits of some of the different coatings available and highlights the advantages that a specialist coatings company can offer.

So why coat at all? The answer is that with electronic systems being used in many environments where there is a chance of chemical contamination – such as fuels, coolants, cleaning fluids etc – complex and costly PCBs need to be protected. Moisture, too can be a killer for sensitive electronic systems, so products that are used in high-humidity atmospheres, or which might be exposed to salt spray will need to be coated. In humid and tropic conditions, corrosion and mould growth can also be prevented by the correct choice of conformal coating.

There are other benefits, too. A conformal coating literally conforms to the shape of the populated PCB forming a kind of shrink wrapped protective envelope. This can dampen the effects of vibration and also help reduce current leakage.

Choice of flavours

In general there are five types of conformal coating products available:

- Acrylic – solvent or water-based
- Silicones
- (Poly) Urethanes
- Parylene
- Fluorocoatings

The 'plain vanilla' coating is acrylic. These materials offer good water and moisture resistance, are suitable for use in products that have a wide operating temperature (-25 to 125°C) and are relatively simple to rework. They offer reasonable protection against salt spray and mould growth, and some vibration dampening. Moreover, some acrylic coatings have been shown to reduce the 'tin-whiskering' effect which has become a concern since the move to lead-free solders.

Original acrylic coatings were solvent-based, but now, more environmentally-friendly water-based products are available that offer the same performance – sometimes even extending the operational temperature range. The downside with acrylic coatings is that they offer a very limited resistance to attack by solvents or other aggressive chemical agents, and so are unsuitable for a range of applications.

Silicones, on the other hand deliver excellent levels of protection against solvents. They are also very good at resisting mould growth, have a higher dielectric strength (90kV/mm versus 45kV/mm for acrylics) which means that designers can use closer tracking and hence reduce size, and are suitable for use at working temperatures as low as -60°C and above 250°C (short peaks at 300°C). However, since silicone coatings – especially if heat-cured are hard to remove, rework will require considerable expertise. Silicone coatings can also be up to 50% more expensive than acrylic types.

A viable alternative

Urethane materials are a good alternative, fitting somewhere between acrylics and silicones both in terns of performance and price. They perform well under solvent attack and offer good all-round protection. However, urethane

coatings can also be tricky to remove especially as they age.

Rework is, perhaps, worth more consideration here. Ideally, there should be no reason to rework a board, but in reality, quite often boards require rework for a number of different reasons. Components may fail, the board may become damaged, or the design may need uprating or require an FPGA to be reprogrammed for example. Acrylic coatings can be spot removed, the component in question de-soldered and removed. With silicone products, the process involves either de-soldering through the coating (depending on the type of silicone coating) or spot removing before any rework is possible.

The complete removal of a silicone coating is extremely laborious (especially heat cured versions). Some urethane materials contain isocyanates which may produce carcinogenic fumes if you attempt to de-solder through the coating. Because of this and the difficulty of removing the coating, great care must be taken when reworking PCBs that have been coated using these types of urethane material.

One further problem that can occur with silicones is particle contamination. Some silicone coatings are prone to volatilisation – i.e. out-gassing of silicone particles – which for some applications makes their use unsuitable.

For example, Chiltern Connections recently undertook work for RAL (Rutherford Appleton Laboratories) on boards that are to be used in instruments aboard the Solar Dynamics Observatory, which will study solar effects from space. In the harsh space environment, extremes of temperature will cause out-gassing. At the ultra-violet wavelengths required to capture solar images, any silicone particles that have out-gassed will pollute the instrumentation absorbing any available light, causing effective blindness and rendering the instruments useless. In this example, and others, urethane coatings were the correct choice. However, modified silicone coatings do exist which have a low volatility, due to low molecular weight, and in some instances – though not for the RAL application – they may be appropriate.

Keeping things uniform

Conformal coating should provide an even coating of equal thickness over the whole board. In reality however, coatings (especially solvented systems) do not produce a perfect contour of equal thickness due to the effects of surface tension and surface conditions. There is one exception, poly-para-xylylene, better known as Parylene. Parylene coatings are applied under vacuum and this produces a uniform coating. Rework can be tricky, so if it does become necessary to make a correction, often alternative spray-on modified silicone coatings are used.

The final technique to be discussed is fluorocoating. This produces a very thin, (two micron) molecular covering, not only of a populated board, but also of any moving parts, such as switching contacts. Fluorocoatings have limited mechanical strength and no solvent resistance, but provide good protection against moisture and water.

Most good coating suppliers can provide their products with optional UV traces. This is a useful aid for inspection purposes, to identify that a board has been coated and to ensure there has been no contamination of connectors, contacts, etc.

Multiple applications

In the past, conformal coating was mainly demanded by military, aero and space customers. Now, however, many more applications are demanding a coating of some type. Just two examples: Chiltern Connections uses an acrylic coating on a board used in domestic boiler systems. This protects against condensation and reduces short circuits. In a marine application, the company protects PCBs used

in sonar buoys against salt spray, oil, and the effects of vibration using a silicone product. The company also has customers in the automotive, medical, military and industrial fields.

The company prefers to become involved at an early stage, so that any coating issues are considered in design, avoiding costly fixes later. For example, the design and layout of a board can affect its ability to be masked, and may also limit the available coating options – spray or dip. Spraying may be more suitable for low run orders and gets around any problems associated with difficult masking, but is it repeatable? Dipping is automated and repeatable, but if any coating gets inside a connector, then there will be a major headache. Early consultation with a specialist conformal coatings company such as Chiltern Connections can help ensure that the correct choice of coating is made and that costly and time-consuming processes are avoided.

Originally printed in EMP magazine December 2006