Get the most out of epoxy potting and encapsulation compounds

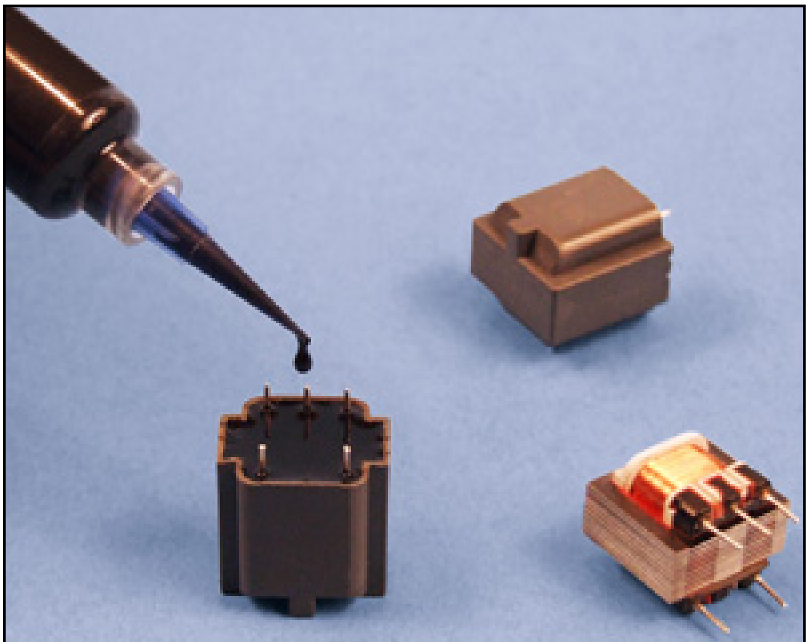
Robert Michaels, VP Technical Sales, Master Bond Inc., www.masterbond.com

Potting compounds are too often an afterthought in the design of electronic devices. They shouldn't be. These encapsulating systems play a crucial role in the assembly and long-term protection of delicate electronic components.

When properly selected and applied, potting compounds form the first line of defense against a wide range of environmental, chemical, mechanical, thermal, and electrical conditions that would otherwise ruin electronic components. When not properly selected and applied, potting compounds may not offer the desired level of protection. Even worse, a poorly chosen epoxy may cause some damage of its own—by curing in such a way that subjects the potted electronic component to unwanted stresses or heat.

Though there are encapsulants based on polyurethane, silicone, and UV-cured acrylic, most potting applications still rely on epoxy compounds. Hands down, epoxies have the balance of mechanical, thermal, electrical, chemical and adhesion properties.

The design tips that follow can help you avoid the more common pitfalls associated with the selection and application of epoxy potting compounds:



Master Bond potting/encapsulation compounds offer easy application and high performance.

First ask, "why encapsulate?" and understand temperature complexities

Start by asking fundamental questions about the purpose of the encapsulation.

Does the potting compound perform a thermal management role? Should it protect against aggressive chemicals or moisture? Does it protect against shock loads? Are optical properties important? Will the potting experience high temperatures during the assembly process? Are there specialty requirements such as low outgassing, cryogenic serviceability or medical biocompatibility? Establishing the functional requirements of the potting compound should be a given, but many engineers still pick potting compounds through trial and error. Asking the right questions early in the design process will keep the errors to a minimum.

Of all the mistakes related to encapsulation design, the most common involves a limited understanding of thermal conditions. Engineers will select a potting compound based solely on the expected maximum and minimum application temperatures. That approach, while seemingly correct, can lead to the wrong potting compound for the job at hand because it fails to account for dwell and ramp times.

Failing to account for dwell time, or how long the potting compound remains at a given temperature, tends to result in over-specifying because most potting compounds, particularly epoxies, can withstand short temperature spikes above their recommended continuous use temperatures.

To take an example, an epoxy potting compound rated for continuous use of 200°C would have no difficulty withstanding a short burst of 250°C during a soldering operation. Engineers who focus only on the maximum temperature and ignore its short dwell time will tend to end up with a more expensive potting compound than they actually need.

Failing to account for ramp times, or the speed of temperature changes, can likewise lead to the wrong potting compound. Fast ramp times and thermal shock go hand in hand. Engineers who ignore ramp times may end up with a potting compound that can meet the high and low temperature requirements but not hold up to thermal cycling without cracking.

Be aware of property compromise

Most materials systems involve trade-offs, and potting compounds are no exception. However, with the right chemistry and additives and fillers, it is now possible to formulate potting compounds whose mechanical, chemical, electrical and thermal properties have been tailored to specific applications. Master Bond EP33 is a good example. It has been formulated to avoid the usual trade-off between high temperature performance and modulus, which gives it the unusual ability to withstand both thermal cycling and high temperatures.

There are also products available that meet specialty requirements such as low outgassing, thermal conductivity, cryogenic serviceability, and more.

Still, there are currently some property trade-offs that are difficult to reconcile given today’s technology. Examples include thermal conductivity and optical clarity because the fillers that make the compound conductive also interfere with clarity.

Potting and encapsulation compounds are widely used whenever electronic components require protection from damaging thermal, environmental or mechanical conditions.

Consider the cure

Engineers with an eye on assembly costs normally want to use potting compounds with a fast cure schedule. While there are plenty of good products that will meet this requirement, including Master Bond EP41S, keep in mind that fast cure reactions tend to generate a larger exotherm than slower reactions, raising the potential for thermal damage. Fast cure systems also have a higher potential for entrapped bubbles, which can reduce the potting compounds' expected electrical and mechanical properties.

The distinction between one- and two-part formulations also matters a great deal in potting applications. Engineers wanting to keep things simple on the assembly floor may favor one-part products since they involve no mixing. There are many good one-part potting compounds, including Master Bond EP2RRLV. Just keep in mind that one-part products require a heat cure that may push extremely heat sensitive components past their thermal limits.

One-component potting compounds also have a more limited range of properties available, so applications that need maximum performance properties should consider two-part systems.

Account for shrinkage and make it stick

Like other polymers, potting compounds shrink as they cure — as much as 2.3 percent for an unfilled epoxy compound. If not accounted for, this shrinkage can impart stresses to the electronic components, open up leak paths, and create visual defects. The good news, however, is that shrinkage can be controlled by selecting the right potting compound. Filled potting compounds and slower curing epoxies tend to exhibit less shrinkage than their unfilled and fast-cure counterparts.

Potting compounds work best if they have good adhesion to their substrates.

Unfortunately, many of the polymers used for electronics housings and potted components frequently have low surface energies and do not bond easily. Poor adhesion with the substrate materials can be fixed early in the design process through the use of surface treatments and primers. Engineers can combat poor adhesion with part features, such as ‘undercuts” that let the cured potting compound “lock” itself into the electronic housing.

Go for the flow
Potting compounds must flow well to encapsulate the electronic components fully and leave no voids in the housing. Achieving this flow is easier said than done. It requires careful attention to the viscosity of the potting compound, which tends to fall in a range between 400 cps to 50,000 cps depending on the application. The geometry of the housing or potting shell in relation to the electric component can also play a role in impeding or promoting flow. One problem to watch out for is pottings with large horizontal surfaces. When top filled, they can entrap air and moisture that can damage electrical components.

As the size of a potting increases, so too does the risk of thermal damage during the potting process. Potting compounds cure exothermically, and these cure reactions can generate heat to damage electronic components. It’s not uncommon, for example, for potting compounds to heat up by 200°C or higher, as they cure. The heat from the exothermic cure is a major issue and will be a primary factor when choosing a potting material, particularly in coatings exceeding thicknesses of 1/4 to 1/2 inch.

Potting size has cost implications too. Larger pottings consume more potting compound and take longer to cure, which can add cost to the assembly process.

For more information visit: www.masterbond.com [1]

Shrinkage isn’t all bad
A bit of controlled shrink can actually be helpful in thermal cycling applications. When the potting compound’s coefficient of thermal expansion (CTE) does not match that of the substrate, a bit of shrinkage can create just enough clearance to relieve stresses caused by differential expansion and contraction.

Source URL (retrieved on *03/08/2014 - 4:51pm*):
http://www.ecnmag.com/articles/2012/05/get-most-out-epoxy-potting-and-encapsulation-compounds

Links:
[1] http://www.masterbond.com