Industry Developments:

Thermal Potting Compounds and Epoxies

Thermal potting compounds and encapsulants are specified to flow over an electrical device and fill up a housing with a hardened thermoset plastic, to serve as an environmental barrier. Epoxy and urethane materials are prevalent throughout industry because they suitably withstand intrusive environmental moisture, salts and chemicals that can attack sensitive electronics and cause shorts.

A majority of potting compounds are epoxies, available in single- and multi-part chemical systems. Potting compounds are typically pourable, filled epoxy resin systems offering excellent heat transfer, high voltage insulation, low exotherm and minimum shrinkage. These compounds transfer heat rapidly, thereby eliminating hot spots and increasing the operating efficiency of most encapsulated devices. The low shrinkage design feature minimizes risk of damage to fragile components.

Thermal epoxies are designed to work as high-performance engineering adhesives and structural adhesives in a wide range of applications and environments. They can be electrically conductive or not conductive, depending on the thermal additive used. Ceramic particles are common non-conductive fillers, and silver or silver-coated particles are typical electrically conductive particles. Usual applications include bonding semiconductors, lid seal, SMD attach, stacking components and die attach applications.

Typical Uses for Thermal Compounds

Thermally conductive potting compounds are an effective way to control heat build-up in an electronic assembly. Epoxies, urethanes and silicones are used to bond heat sinks, encapsulate power supplies and individual components and protect motors from overheating.

Thermal compound products like these are designed for protecting components in applications such as densely packaged power supplies and heat generating components, integrated circuits, power and operational amplifiers, transformers and many types of semiconductors. Most potting compounds will cure at ambient temperatures; however, many will cure faster at specified elevated temperatures. Potting compounds may also be referred to as encapsulants.

Choosing a thermal potting compound or epoxy should involve a number of factors. These include the temperature range of use; environmental conditions, such as sunlight and humidity; regulatory issues, e.g. is UL V-0 flame resistance required; and the overall size of the application.

Engineering and design considerations for epoxies and potting compounds are: dielectric strength, thermal, mechanical, vibration, rigidity, flexibility, time for processing, material compatibility, out gassing, resistivity and coefficient of expansion. Other considerations are potting compound viscosity, application temperature, handling and storage, curing temperature, curing time requirements, post cure requirements, standards compliance and maximum handling time or pot duration. [2]

Application Notes

When applying thermal epoxy, it is very important to use the least possible amount required to fill any voids and make the bond. If a too-thick coat of epoxy is applied, the electrical conductivity of the epoxy will be degraded. Once the epoxy has cured, the bond between the two surfaces is permanent. Epoxies should only be used in well-ventilated areas, and the manufacturer's instructions should always be followed for best results. [1]

Potting compound enclosure requirement should also be considered during the mechanical design phase to ensure proper access, potting compound flow and compound setup and handling [2]

Printed circuit boards that have components that generate high amounts of heat present problems when they are potted. The design engineer wants the potting compound to dissipate the heat, so they specify thermally conductive potting compounds. This would seem like a logical idea, but thermally conductive potting compounds have problems and much higher cost for very little increase in heat removal.

Thermally conductive potting compounds generally have thermal conductivity of 10 Btu/hr-ft^{2}-°F (1.44 W/m•K). Normal potting materials are 2 Btu/hr-ft^{2}-°F (0.288 W/m•K) when filled with calcium carbonate and 1 Btu/hr-ft^{2}-°F (0.144 W/m•K) when unfilled. Comparing that to air at 0.01 Btu/hr-ft^{2}-°F (0.00144 W/m•K), it seems pretty good, but when compared to aluminum at 1200 Btu/hr-ft^{2}-°F (173 W/m•K), potting materials have very low conductivity. This is why we suggest heat sinks as the primary means to remove the heat, even though the difference between thermally conductive and normal potting compounds is 5 times the difference between two small numbers, which is small when compared to the very high number of aluminum's heat transmission. [3]

The pot life also depends on the amount of material mixed and the temperature of the system. It considerably decreases with an increase in temperature; therefore, working time is much shorter at higher temperatures.

In many applications, a long pot life is desired due to application requirements. Some of the applications where a long pot life is necessary include large potting applications and coating or bonding very large surface areas. In such cases, a long open time is preferred to make the application process easier. Another important factor to be considered especially in potting, encapsulation and casting applications is the exotherm, or evolution of heat, involved in the curing reaction. [4]

A thermally conductive potting material can lower hot spot temperatures – the temperature next to the component. This is because it has a higher specific heat i.e.; can absorb more Calories or BTUs. Its filler requires more BTU's or calories to raise the temperature. Your decision to use a thermally conductive potting compound is basically determined by how sensitive the component is to the thermal rise.

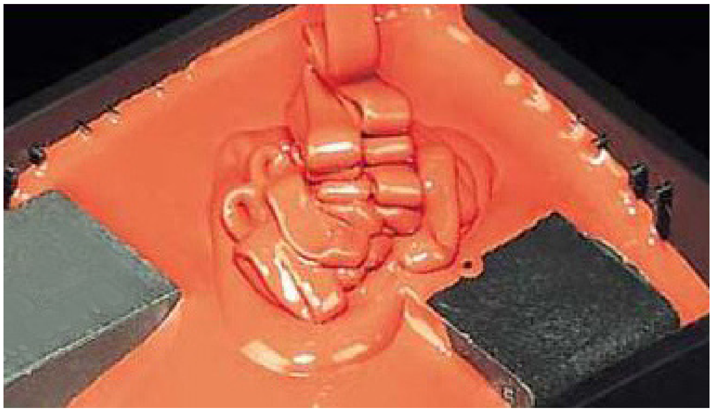

Figure 1. Applying a Thermal Potting Compound.

EPOXICAST-1015 from EpoxySet is a low viscosity epoxy potting compound which is regarded as excellent for potting densely packaged electronic parts. EC-1015 has a very long pot life, making it a great option for high volume use. This material cures in four hours at 125°C. Curing at this high temperature results in high heat resistance, glass transition temperature over 140°C, and more efficiency. This product offers resistance to acids, alkalis, organic fluids, and salts as well. EC-1015 is useful for potting and encapsulating densely packaged power supplies, rectifiers, integrated circuits, thick film hybrid devices, digital-analog converters, oscillators, amplifiers, relays, transformers and semiconductors. It is available in pint, quart, gallon, and 5-gallon kits. [5]

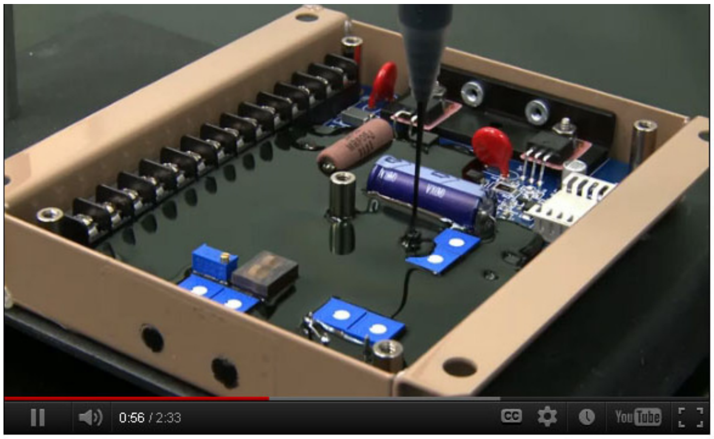

Figure 2. A Video by Epoxies, Etc. Shows the Application of a Flame Retardent Thermal Epoxy Resin. [6]

Epoxies, Etc. has introduced 50-3150 FR, a flame retardant thermally conductive epoxy resin that provides heat transfer, low shrinkage and insulation properties. Typical applications include encapsulating power supplies, transformers, coils, insulators and sensors. The resin system is formulated to meet the stringent non-burning requirements of UL94 V-0. [6]

Automated Applications

GF 300 compound from MH&W is a ceramic-filled, two component silicone elastomer. It is free of solvents and can be used for encapsulating or dispensing. Compounds like these are provided in a wide range of different material viscosities, making them usable for "wet-in-wet" production. Applications include RD-RAM modules, chipsets, memory chips and high voltage electronic components. [7]

Figure 3. Some Thermal Compounds Can be Machine Dispensed. [7]

Put The Metal Down?

Metals such as silver and copper are generally the best conductors of heat. Because of their electrical conductivity, thermal compounds containing metals must be carefully applied when used to address a heat transfer challenge in an electronic assembly, such as a printed circuit board with transformers or a power supply attached.

One of these thermal compounds, Arctic Silver 5, is a high-density, polysynthetic silver-filled compound that is non-electrically conductive under normal use. The compound has a unique high-density filling of micronized silver and enhanced thermally conductive ceramic particles. It can be used on a wide range of bond lines between modern high-power CPUs and high performance heat sinks or water-cooling solutions. Arctic Silver 5 contains over 88% thermally conductive filler by weight. In addition to micronized silver, Arctic Silver 5 also contains sub-micron zinc oxide, aluminum oxide and boron nitride particles. These thermally-enhanced ceramic particles improve the compound's performance and long-term stability. Arctic Silver reports that use of this material results in 3 to 12 degrees centigrade lower CPU full load core temperatures than standard thermal compounds or thermal pads, when measured with a calibrated thermal diode embedded in the CPU core. [8]

Conclusion

Potting compounds may be used to provide an environmental barrier, dielectric protection characteristics, thermal conduction paths, and structural enhancement of an assembly or component. Many thermal epoxies are designed for the demanding needs of die-attach heat sink bonding and surface mount applications. Good heat transfer capabilities, and filling in the gaps, will eliminate hot spots. Their low epoxy shrinkage factor minimizes the risk of damage to fragile components, resulting in increased operating efficiencies.

References:

1. **Wisegeek.com http://www.wisegeek.com/what-is-a-thermal-epoxy.htm**
2. **Engineersedge.com http://www.engineersedge.com/materials-chemicals-adhesives/potting-compounds.htm**
3. **Pottingsolutions.com http://www.pottingsolutions.com/my%20site/Technology/potting_hints.htm**
4. **Masterbond, http://www.masterbond.com/techtips/long-potworking-life-combined-low-exotherm**
5. **Epoxyset, http://www.epoxyset.com/#**
6. **Epoxies, Etc., http://www.epoxies.com/video-50-3150FR.htm**
7. **MH&W Inc., http://www.mhw-intl.com/assets/sealCmpd_GF300_GF1000.pdf**
8. **Arctic Silver, http://www.arcticsilver.com/as5.htm**