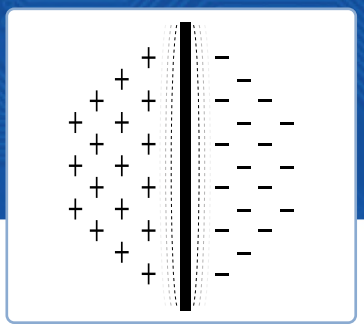
TECH TIP 25

EPOXY TECHNOLOGY

Dielectric Properties of Epoxies



WHAT

Dielectric Properties of Epoxies

WHY

Dielectric materials provide an insulating barrier between two electrical conductors.

Dielectric, by definition, means any insulating medium which intervenes between two conductors. In simple terms, it suggests the absence of conduction and describes materials which are not electrical conductors. Dielectric materials can be used for making capacitors, providing an insulating barrier between two conductors (as in cross over and multi-layered circuits) and for encapsulating circuits. Dielectric properties, specifically for epoxy adhesives, refer to the electrical properties of a material.

Epoxy Technology, Inc. is a DSCC (Defense Supply Center Columbus) approved military testing lab for epoxy adhesives (military standard MIL-STD 883H / Test Method 5011-5). This standard involves several adhesive tests: Volume Resistivity (VR), Dielectric Constant (Dk) and Dissipation Factor (Df), but does not include Dielectric Strength as it is application dependent.

If a material is certified to the above standard, it is a great candidate for evaluation in high reliability applications, such as military or aerospace. Many companies require this certification for consideration in their design phase.

Dielectric Properties

There are four dielectric properties typically associated with epoxy products: VR, Dk, Df and dielectric strength. For epoxies, here are some general guidelines:

> Volume Resistivity (VR) is defined as the measured electrical resistance through a material when a voltage is applied for a specific amount of time. For an insulative product, it is generally greater than or equal to 0.1 teraohm-meter at 25°C and greater than or equal to 1.0 megaohm-meter at 125°C, according to ASTM D257.

> Dielectric Constant (Dk) is defined as a material's ability to store a charge when used as a capacitor dielectric. It is usually less than or equal to 6.0 at both 1 kHz and 1 MHz, according to ASTM D150, and is a unit less value because it is measured in ratios.

> Dissipation Factor (Df) (also called loss factor or dielectric loss) is defined as the power dissipated by a dielectric, generally less than or equal to 0.03 at 1 kHz and less than or equal to 0.05 at 1 MHz, according to ASTM D150.

> Dielectric Strength (sometimes referred to as breakdown voltage) is the maximum electric field a material can withstand before breaking down. It is an important property for many applications that will be running a high current or amperage. *As a general rule-of-thumb, the dielectric strength of an epoxy is roughly 500 volts/mil at 23°C for an insulating product.* As a practical example, if an electronic circuit needs to resist 1000 volts, a minimum of 2 mil of dielectric epoxy is required.

Volume resistivity, dielectric constant and dissipation factor can be experimentally determined by an adhesive manufacturer, however, dielectric strength is application dependent. Epoxy users should always validate the adhesive for its dielectric strength in their specific application.

Variability of Dielectric Properties

Many dielectric properties will vary with respect to factors unrelated to the bulk material properties such as: temperature, frequency, sample size, sample thickness and time. Some external factors and how they affect the end result are:

VR and Temperature > When the temperature of a material increases, VR will decrease. In other words, it will become less of an insulator. The main reason is that the material is above its glass transition temperature (Tg) and molecular motion of the monomers intertwined in the polymer network is at its highest level. It not only means less insulation compared to room temperature, but also can result in lower strength and hermeticity.

Dk and Temperature > Similar to the explanation above, this property will also change with respect to temperature. The dielectric constant of a room temperature cured epoxy will increase with increasing temperature. For example, a value of 3.49 at 25°C will change to 4.55 at 100°C and 5.8 at 150°C. In general terms, the higher the Dk value, the less electrically insulating a material will be.

Dk and Radio Frequency (Rf) > In general, as frequency increases, Dk will decrease. As described in the effect of temperature on Dk, a room temperature cured epoxy with a Dk value of 3.49 at 60Hz will result in a value of 3.25 at 1KHz and 3.33 at 1MHz. In other words, as Rf increases, so does the insulation properties of the adhesive. Thus, the lower the Dk value, the more of an insulator the material will become.

Common Applications

Dielectric adhesives are used in most semiconductor and electronic packaging applications. A few examples include: semiconductor flip chip underfill, SMD staking on PCB and substrate, wafer passivation, glob top over IC's, copper coil impregnation and general PCB potting and encapsulation. All of these areas require the utmost insulation for eliminating and preventing any electrical short-circuit.

Dielectric Products

Epoxy Technology offers several products for dielectric applications providing a combination of structural, optical and thermal properties along with their great dielectric characteristics. All dielectric products are electrical insulators, but many are thermal conductors, too. The below product chart highlights our best dielectric epoxies and some of their uses.

PRODUCT	APPLICATION DESCRIPTION	ELECTRONIC PACKAGING FORMAT
353ND	Cu coil impregnation, SMD inductors, HDD voice coils, piezo ceramic lamination	Power Electronics, Data Storage, Medical Ultrasound
360	Flip chip, CSP or BGA underfill	Semiconductor, PCB
730	Dielectric over DBC ceramic substrate	CPV Solar Cells
930-4	Ferrite bonding, SMD motor coils	Power electronics, IC, SMD
H65-175MP	SMD attach, Opto-packaging, Hybrids	Semiconductor, Military, Avionics
H67-MP	SMD attach, Opto-packaging, Hybrids	Military, Avionics
H67MP-GB	SMD attach, Hybrids, Heat sinking	Military, Avionics
H67MP-T	SMD attach, Hybrids, Heat sinking	Military, Avionics
H70E	Hybrid die attach, SMD attach, COB Die Attached	Hybrid Rf Microwave, FO Components
H77	Potting D-shaped connectors	Electronic Cabling
T7109	Kapton heater coil to metal clad PCB	Medical Electronics
T7110	Potting and encapsulation of PCBs	Electronics
T905BN-3	Thermal potting of transformer cases	Hybrid Avionics

REACH COMPLIANCE
RoHS COMPLIANT
MIL STD 883/5011 COMPLIANT
ISO 9001 COMPLIANT

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