Choosing an Encapsulant to Minimize Stress

Three distinctly different types of high purity, liquid encapsulants - epoxies, silicones, and UV light-curable urethanes offer successful strategies to protect micro-electronic devices. However, each resin's curing requirements result in very different assembly costs. UV light-curable urethanes cure at low temperatures in seconds while epoxies and silicones can require hours at 150°C or more.

High-Performance Protection

In order to protect chips and components, it is necessary that there be no abrupt changes in the resin's physical form which might induce stress on the device. As wires become finer and bonds more delicate, the strategies to overcome the stresses inherent in the materials and between adjacent bonded surfaces have become more exacting.

Strategies That Minimize Stress

Rigid Resins (Epoxy) Strategy

High levels of mineral fillers lower the measured bulk CTE (not the CTE of the base resin), attempting to match the CTE of substrates.

- Epoxies with high T_gs (80-100°C) are mineral filled to yield even higher measured T_gs (to 150° C). It is assumed that if the T_g is above the thermal operating range of the device, high dimensional change and stress in the device will be avoided. High T_g resins exhibit high modulus.

Flexible Resins (Silicone and UV Light-Curable Urethane) Strategy

Typically not filled in order to take advantage of their inherently low modulus.

- Since CTE's can never be matched, low modulus is more effective in lowering stress (even with larger CTE differences between resins and substrates). T_gs are maintained below or near the lower end of the operating range of the device.

Stress/Strain Relationships

Figure 1 shows that high-modulus resins such as epoxies characteristically develop high stress rapidly with only small physical changes. Stress is much lower, and builds more slowly, with dimensional changes in flexible resins.

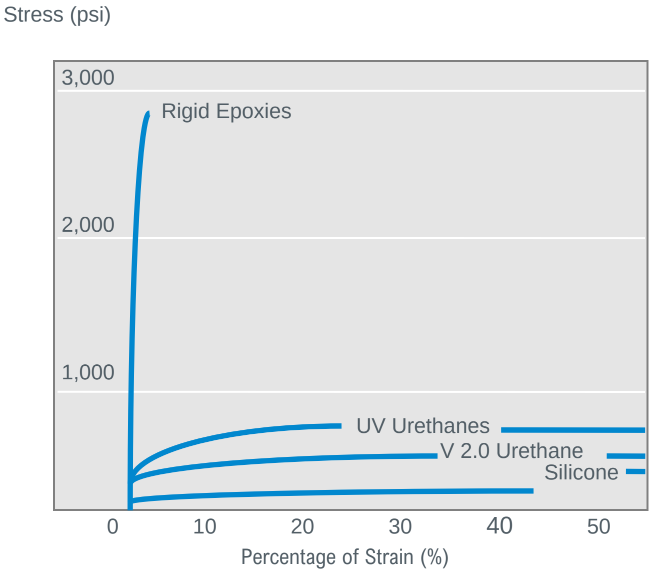


Figure 1. Material Stress with Added Strain

Flexible Encapsulating Resins Minimize Shear Stress

Liquid Encapsulating Resins	Coefficient Thermal Expansion, $x 10^{-6}$ in/in/°C	Modulus of Elasticity (psi)	Relative Shear Stress -55/125°C, (psi)
Base Epoxy Resin	70	750,000	7,546
Filled Epoxy	20	1,500,000	1,593
Flexible UV Urethane	200	3,000	100
Version 2.0 UV Urethane	250	400	17
2-Part Silicone	340	250	15

Table 1. Relative Shear Stress Due to Thermal Expansion from-55/125°C for Rigid and Flexible Resins Against Gold Circuitry

High-modulus resins can transfer more shear stress to components, wire bonds, gold ball or solder connections, etc., than low-modulus resins. Figures 2 and 3 below compare some of the differential stresses that various resins can transfer to adjacent component parts.

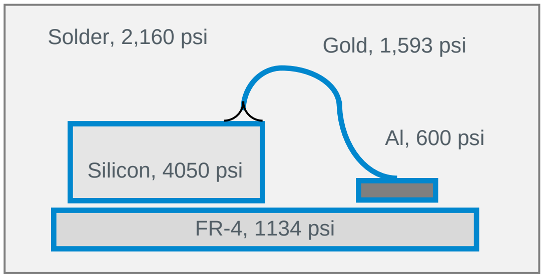


Figure 2. Filled Epoxy

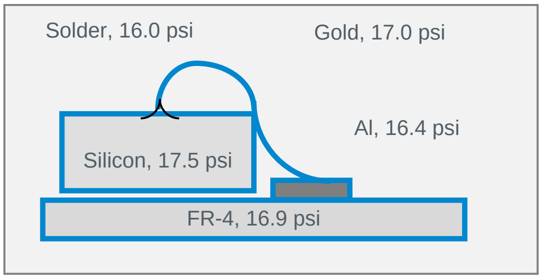
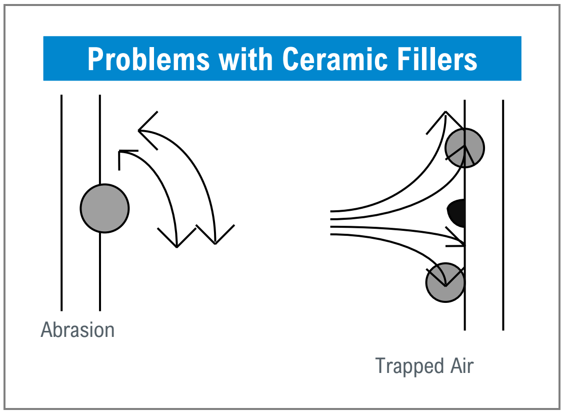


Figure 3. Version 2.0 UV Urethane

Other Particulate Fillers Effects



Though highly-filled epoxy resins are used successfully for protecting delicate microelectronic circuitry, there can be drawbacks. The base resin always has a much higher CTE than the mineral filler. Figure 4 shows how the organic portion of an adhesive can move a filler particle against the wires on a device. The cumulative effect of many thermal cycles (power on/off) can be abrasive to the wire. Fillers can also inhibit the flow of high-speed dispensers, as well as limit free flow around wires or under ball grid arrays leading to air gaps.

Excerpted from Central Texas Electronics Association presentation, May '95.

© 1995-2022 Dymax Corporation. All rights reserved. All trademarks in this guide, except where noted, are the property of, or used under license by Dymax Corporation, U.S.A.

The data contained in this bulletin is of a general nature and is based on laboratory test conditions. Dymax does not warrant the data contained in this bulletin. Any warranty applicable to the product, its application and use is strictly limited to that contained in Dymax's standard Conditions of Sale. Dymax does not assume responsibility for test or performance results obtained by users. It is the user's responsibility to determine the suitability for the product application and purposes and the suitability for use in the user's intended manufacturing apparatus and methods. The user should adopt such precautions and use guidelines as may be reasonably advisable or necessary for the protection of property and persons. Nothing in this bulletin shall act as a representation that the product use or application will not infringe a patent owned by someone other than Dymax or act as a grant of license under any Dymax Corporation Patent. Dymax recommends that each user adequately test its proposed use and application before actual repetitive use, using the data contained in this bulletin as a general guide.