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## **Bonding Dissimilar CTE Materials**

When bonding materials that have different Coefficient of Thermal Expansions (CTE), there are several factors that have to be addressed to ensure long term adhesive joint integrity. Matching the CTE values of each substrate as closely as possible will make life easier but this may not be possible in the real world. When different substrates with their different CTE values are combined with the CTE value of the adhesive, this leads to a complicated matrix of factors. These factors are especially important when the parts will be highly stressed from exposures to low temperatures, thermal cycle, thermal shock or mechanical shock.

An adhesive property that comes into account when talking about CTE is glass transition temperature (Tg). The CTE values are usually lower when the material is below the Tg and is in the rigid or "glassy" region. The CTE values are much higher when the material is above the Tg and is in the flexible or "rubbery" region.

Adhesives usually have a higher CTE value than most common substrates. Highly filled adhesives can equal or approach the CTE values of common substrates. Since exact CTE matching is rare, a variety of methods are used to compensate for mismatches.

### **Curing Conditions**

The mismatch of CTE values causes stress in the bonded assembly. Cure conditions can make a difference in the bond stress. A high temperature, rapid cure will create the most stress that could cause cracking, shrinkage, and cohesive or adhesive failure. The following suggestions may help relieve stress caused by curing.

- Low temperature curing results in a very slowly cured, evenly crosslinked material which minimizes stress buildup between CTE mismatches.
- A step cure can be used if the application requires high temperature or chemical resistance. Gel or cure the assembly at a low temperature and then finish the cure at an elevated temperature.
- If an assembly is to be used at high temperatures, the final cure temperature should be at or above the actual use temperature.

### **Material Rigidity**

Depending on the application requirements, the rigidity of the adhesive is another way to relieve stresses of mismatched CTE values.

A flexible or semi-flexible adhesive allows movements caused by CTE value mismatches to be absorbed by the adhesive. This relieves the bond stress and compensates for movement of substrates because of thermal excursions. Typical use would be for delicate components.

A rigid material prevents any movement at all in the assembly. The adhesive would hold the substrates and adhesive together keeping CTE mismatch movement to a minimum. Typical use would be if the strength of the assembly is the most important property and the substrates are strong enough to withstand the CTE mismatch movement.

The choice of the rigidity of the adhesive is dependent upon the application and the components or substrates to be bonded.

### **Fillers**

Highly filled adhesives will reduce the CTE values of the adhesive and will reduce the resulting stress on the assembly. The stress is reduced even if the CTE values are not matched. Filled materials are even more effective in reducing stresses when low stress curing conditions are used.

If you have any questions or need any additional information call Emerson & Cuming Technical Service at 1-800-832-4929.

Listed on the back are the CTE values for a number of standard Emerson & Cuming products as well as common substrates.

## Coefficients of Thermal Expansion Standard Products and Common Substrates

Common Substrates	CTE(x 10 <sup>-6</sup> /°C)	Standard Products
Quartz	0.56	
Silicon	2.9	
Aluminum Nitride	4.4	
Tungsten	4.5	
Kovar	4.7	
Molybdenum	5.2	
Alumina and Tantalum	7.0	
Sapphire	7.6	
Mica	8.0	
Beryllia, Platinum	8.5	
Cast Iron	10.6	
Stainless Steel 410, Steel 1010	11.7	
Nickel	13.0	
Gold	14.0	
Polyimide-glass	14.5	
Copper, Beryllium	16.7	
Stainless Steel 302, 304	17.3	
FR-4, G-10, FR-5 Epoxy-glass	17.5	
Brass	18.4	
Silver	19.1	
Tin	20.0	STYCAST® 2850 KT/Cat 9, Cat 11
	25.0	STYCAST 2850 MT/Cat 11
Aluminum	27.0	STYCAST 2850 GT/Cat 11 or ECCOBOND® 276 A/B
	29.0	ECCOBOND 285/Cat 11
	31.0	STYCAST 2850 FT/Cat 11
Zinc	32.5	ECCOBOND 281
	33.0	STYCAST 1495/Cat 11
	36.0	ECCOBOND 286 A/B
	38.0	STYCAST 2762/Cat 17 M 1
	40.0	STYCAST 2651, STYCAST 1090, STYCAST 2651 MM/Cat 11
	43.0	STYCAST 2057/Cat 23 LV
	45.0	ECCOBOND 83 C/Cat 9 or Cat 11, ECCOBOND CT 5047-2 A/B
	47.0	STYCAST 2662 A/B, STYCAST 1495/Cat 23 LV
	55-85	ECCOBOND 45 or STYCAST 2741 with Cat 15 (variable mix ratios)
	60.0	STYCAST E 151-3
	150	STYCAST 4954, STYCAST 5954
	200	STYCAST 4122
	300	STYCAST 5019

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