Electrically Conductive Silicone Adhesives

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INTRODUCTION

Today's high density circuitry and high power requirements demand bonding materials which provide good electrical contact and thermal transfer. These properties are available in a series of silicone based adhesives which do not require closely matched coefficients of thermal expansion (CTE) of the bonded layers.

Effective electrical contact and thermal transfer can be achieved with heat curable electrically conductive silicone adhesives.

ELECTRICALLY CONDUCTIVE ADHESIVES

When electrical continuity and/or thermal transfer is needed between the irregular surface of a printed circuit board (PCB) and either a back plane or heat sink, use of these heat curable materials provides a reliable bond and offers ease of application while accommodating variations in PCB topography and CTE.

Since the materials are highly compliant prior to cure, they easily conform to fine or complex traces regardless of thickness or depth. Where differences in CTE are undesirable, bonding with these adhesives acts to decouple dissimilar materials, reducing stress and avoiding opportunities for delamination of the circuit board. Because the material is still elastic after cure, it will absorb differences in expansion and contraction of the bonded surfaces without damaging either surface or the adhesive bond.

Electrically conductive adhesives are also useful for isolating areas on the PCB for EMI/RFI shielding. Shielding effectiveness and bonding characteristics of the adhesive are not degraded by exposure to solder temperatures so that they may be applied prior to component insertion.

Electrically conductive adhesives achieve their low resistivity through the addition of fine metal powders, specifically silver-plated aluminum, during the compounding operation. For applications in which greater resistance to corrosion, salt spray, and galvanic reactions is desired, a compound has been developed using particles of pure nickel, which proved effective in successfully passing a 1000-hour salt spray test. (This compound is stabilized but free of chromates.)

The different formulations available provide a gradation of shielding effectiveness to suit various requirements (Table 1). As well as being electrically conductive, all four adhesives are thermally conductive, for good heat dissipation. Some are further developed and formulated to meet low outgassing requirements of certain aerospace applications.

Contact area is critical to adhesive effectiveness. Precured materials lose up to 30-percent contact on rough or irregular surfaces. Silicone adhesives offer 100-percent contact for an intimate and efficient approach to thermal and electrical conductivity.

For most applications the standard 0.010-inch thickness is advisable. However, in some situations a thicker section may be needed. For additional flexibility, many shapes and hole patterns are available which can be readily dropped into place.

One caution should be noted. Care must be used in handling sensitive areas of the circuit board after touching silicone adhesives. If conformal coating or painting is required subsequent to bonding, masking should be used before the cure cycle to prevent poor adhesion of these or other coatings.

PREPARATION AND USE

Silicone-based adhesives provide consistent results if they are applied according to the following directions.

1. The areas to be bonded are cleaned of all grease, fingerprints, dust, and other contaminants. If a Teflon™ surface is involved, it must be etched or abraded with a fluoroetchant or plasma discharge. If a board has recently been etched of ED

PROPERTY				
Base Material	Silicone	Silicone	Silicone	Fluorosilicone
Thermal Conductivity (BTU-In/Hr/Ft²/°F) (Cal/Hr/CM²/°C)	15/18.6	5.5/6.8	13.4/16.6	5.9/7.3
Durometer (Shore A) (ASTM D 2240) +7	65	55	80	85
Specific Gravity (ASTM D 792)	2.0	1.9	2.2	4.8
Tensile Strength (ASTM D 412, M.A., D.C) PSI/MPA Min.	100/.69	330/2.28	96/.66	600/4.2
Elongation Min./Max. % (ASTM D 412)	100-300	250-400	100-300	35-300
Tear LB/In-Kn/M (ASTM D 624, DIE B)	28/4.91	80/14.0	34/5.96	70/12.3
Shear Strength (ASTM D1002) PSI/MPA	85/.6	500/3.5	180/1.3	60/.4
Shear Modulus (ASTM D 3983) PSI/MPA	45/.3	50/.4	85/.6	65/.5
Available Thickness Low to High	10 to 60	10 to 60	10 to 60	20 to 60
Continuous Use Temp °C	-65/+200°	-65/+200°	-65/+200°	-65/200°
Volume Resistivity (ASTM D 991 MOD)-Ohm-Cm.	.008	1.2	.002	.05.
Filler	Ag/Al	Ag/Al	Ag/Al	Nickel
Low Outgassing (ESA PSS-01-702) (ASTM E 595)(NASA SP-R-0022A)				
Total Mass Loss	NA	0.13%	0.13%	NA
Col. Vol. Cond. Matl.		0.01%	0.01%	
Water Vap. Recovered		0.03%	0.03%	

TABLE 1. *Shielding Effectiveness of Selected Formulations.*

copper, it will accept a bond without further treatment. Aluminum surfaces are best cleaned with Scotchbrite™ and then, to remove any residue, with a solvent that leaves no film.

2. Both surfaces are coated with the primer provided, using a cotton litho pad, cotton swab, or a thin layer of lint-free tissue. This puts down a very thin layer of primer. Excess primer acts as a release and can cause debonding. Therefore, the primer is only coated once. Drying and activating time is a minimum of 30 minutes, no longer than eight hours. Relative humidity, important for activation of the primer, is recommended at 40 to 60 percent. The primed surfaces should not be handled.

3. The release liner is removed from one side of the adhesive sheet, by starting at the corner and pulling at 180° to the surface. Should an edge begin to tear, the liner is slid back over the area and rubbed gently. The adhesive will reflow to itself without causing a break.

4. Adhesive is applied to one of the cleaned and primed surfaces to be bonded. Starting at one corner, the adhesive is removed, rolled and gently pressed into place.

5. The remaining release liner

is removed as in Step 3.

6. The second surface is applied to the adhesive layer, as in Step 4, rolling the material as much as practical to avoid trapping air.

7. The assembly is affixed together with light pressure. It is now ready for heat curing. Slight movement of the adhesive or surfaces may occur during curing, but the adhesive will not "flow" on the perimeter of the part.

8. The assembly needs some pressure to ensure electrical conductivity. A vacuum bag, clamps, or low pressure press may be used if they provide the minimum recommended 14 psi. Higher pressures may be used, but may cause some adhesive to squeeze out, requiring post-cure cleanup and possibly contaminating areas of the board where solder wicking is desired.

9. The assembly is cured at 250°F for 15 minutes. This material is thermoset and cannot be remelted or reused once cured. Prior to cure, rework and repositioning are possible.

FEATURES AND BENEFITS

Electrically conductive silicone adhesives offer many advantages over alternative materials. Coefficient of thermal expansion is not a factor in bonding dissimilar materials since movement caused by temperature cycling will not effect electrical conductivity. Low temperature flexibility is good down to -65°F. Silicone is effective up to 20 years, stable to 400°F. Grades are available for aerospace applications to meet NASA, SAE, and ASTM requirements (Table 1).

SUMMARY

Electrically conductive silicone adhesives offer many advantages over traditional film adhesives. The silicone base negates the requirement for matching coefficients of thermal expansion of the bonded layers. The adhesives can be applied to irregular surfaces and numerous formulations provide levels of shielding effectiveness to suit many requirements.

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