KEMET® TECHTOPICS
... THE LEADING EDGE
VOL. 2, NO. 7 • PUBLISHED BY KEMET ELECTRONICS CORP. • P. O. BOX 5928 • GREENVILLE, SC 29606 • (864) 963-6300 • SEPTEMBER 1992

The thermal requirements for surface mounting tantalum chip capacitors preclude the use of lead-tin solders traditionally used in assembling leaded capacitors. As solders were replaced with conductive adhesives, new tests were required to evaluate and optimize these ma-materials.

This Tech Topic, by F. E. (Toots) Motisher, a Senior Staff Engineer in KEMET's Technology Department describes some of the evaluation techniques she developed.

Dr. John Piper
Vice-President — Technology

Evaluations of Silver Adhesives for Tantalum Chip Manufacture

by F. E. Motisher

Introduction

To produce a rugged surface mount tantalum chip capacitor, the processed anode must be assembled such that it is connected at both the positive and negative leads by high performance (electrical and mechanical) bonds. At KEMET, the bonding material chosen for the negative lead attach is an electrically conductive adhesive.

Choosing to use an adhesive in the process implies an ability to test such a raw material for its effectiveness. Implicit in the testing process is the notion that the proper tests are being conducted. At KEMET, the quality control issues have been revisited with an emphasis on building a program that will fully characterize this important raw material.

Back to Basics

Using the KEMET Advanced Quality Planning System, the "voice of our internal customer", was documented in a series of key requirements which found their way into a QFD House of Quality format. These requirements assess the intrinsic character of an adhesive and make it possible to qualify its appropriateness for capacitor manufacture without the costly use of production facilities. It was determined that to be effective, the adhesive must:

- stick to both substrates (anode and leadframe)
- be electrically conductive
- be dispensable
- remain homogeneous under pressure
- look good (microscopically).

A suite of methods, including fixturing devices and measuring probes, was developed from these key requirements objectively describing the mechanical, electrical, and rheological differences between potential adhesives.

What is not readily obvious when discussing the laboratory testing of glue is that it is also necessary to discover a material to which the adhesive will not adhere. Finding a test specimen hopelessly bonded to a test fixture normally provides the impetus for beginning the search. Most epoxy adhesives have the propensity to out and touch" all machinable substrate materials - the single exception being Teflon coated surfaces. Accordingly, all fixturing devices were designed to prevent adhesive overflow onto the fixture or were provided with Teflon protection.

Viscosity

Of the tests developed, the easiest to perform and tabulate (and possibly the hardest to interpret) is the viscosity value. Simply stated, viscosity is the ratio of shear stress to shear rate and is measured in a viscometer by determining the amount of torque necessary to maintain the angular velocity of the rotating spindle. This number describes the fluid properties of the glue and hence the characteristics used to describe dispensability: controllable dot size, dot profile, sag and flow.

Viscosity is determined using a Haake Cone and Plate viscometer. A small amount of the test material is introduced between a stationary plate and a cone. Upon rotating the cone, a certain amount of flow is created within the material. This flow, or resistance to flow, is a measure of the viscosity of the adhesive under test. Figure 1 schematically describes viscosity measured in a parallel plate unit.

Conductivity

For an adhesive to be suitable for bonding the negative lead of a capacitor, it must display a high degree of electrical conductivity. To accommodate test equipment, the conductivity of a specimen is actually determined by its lack of resistance.

Resistivities (ρ) are determined with a micro-ohm meter and a four-point probe, using the relationship that $R = \rho l/A$, where R is the resistance in ohms, l is the length between the probes (cm) and A is the sample area (thickness x width, cm^2) of the cured adhesive. In assessing very low resistances, a four-point probe is necessary to eliminate the contact resistance of the measuring devices.

Meaningful data only can be generated if the analyst is capable of preparing samples of consistent width and thickness.

Volume (bulk) Resistivity

For thick adhesive samples, chemically milled masks are attached to a glass substrate and the adhesives are screened through the mask. Because the most fluid samples tend to bleed under the masks, this procedure was not followed at KEMET.

Masks are now prepared in situ by placing tape on the glass substrate and cutting out a window of known size and shape using a template. The adhesive is then doctored onto the substrate filling the window to the thickness of the tape left at the borders.

Interfacial Resistivity

Fairly simple devices were prepared to maintain contact area and adhesive thickness while preparing samples for the measurement of the interfacial resistivity at the leadframe/adhesive bond area.

As with the preparation of bulk resistivity samples, the procedure for preparing specimens to test for anode dip coat/adhesive interfacial resistivity was accomplished using in situ masks.

Figure 2 describes probe-ready samples.

Peel Strength

Adhesive manufacturers typically publish adhesive strength data from lap shear tests. These tests generate very high values for most of the glues appropriate for capacitor manufacture. At KEMET, it was determined that the failure mode for the adhesive joint in a capacitor is not due to shear stress but to peel stress. Accordingly, the lap shear data does not provide meaningful information for our product.

Unfortunately, while lap shear testing is relatively simple, peel strength tests are very difficult to perform. The measurements are only as good as the specimen preparation preceding the data acquisition step. The test requires flexible adherents separated by a known volume of adhesive, cured to a specific thickness while fixed in a specified orientation.

At KEMET, the logical choice for adherent material is the leadframe that forms one interface at the capacitor's negative lead attach site. The sample preparation procedure has evolved through a number of generations and now involves an in situ mask and a resident spacer to control adhesive volume. After the adhesive is screened onto the leadframe, the peel strength couple is then placed into the fixturing/curing device.

The fixturing device has also gone through a number of iterations, the current model providing for the simultaneous curing of two samples. As shown in Figure 3, the cured specimen is prepared for testing by cutting and bending and is placed in the opposing jaws of an Instron machine to be pulled apart in the indicated direction. The shape of the peel strength curves can describe the nature of the adhesive break.

A cohesive failure, in which the adhesive breaks within its own matrix, is very smooth with little variation in the magnitude of the peel strength. An adhesive break, where the failure site is at the interface between the adhesive and the leadframe, results in wide swings in the magnitude of the apparent strength of the test material.

Conclusion

Understanding the intrinsic properties of electrically conductive adhesives has given KEMET greater insight into the practical control of handling and dispensing these materials on the production floor.

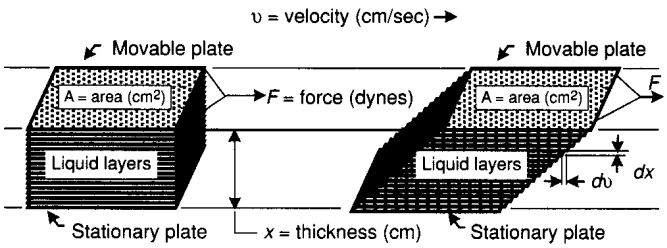

Fig. 1

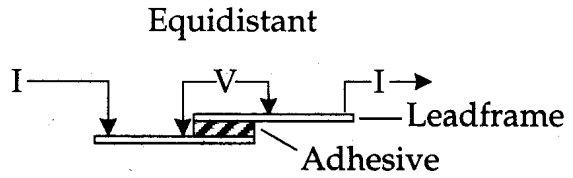

Fig. 2

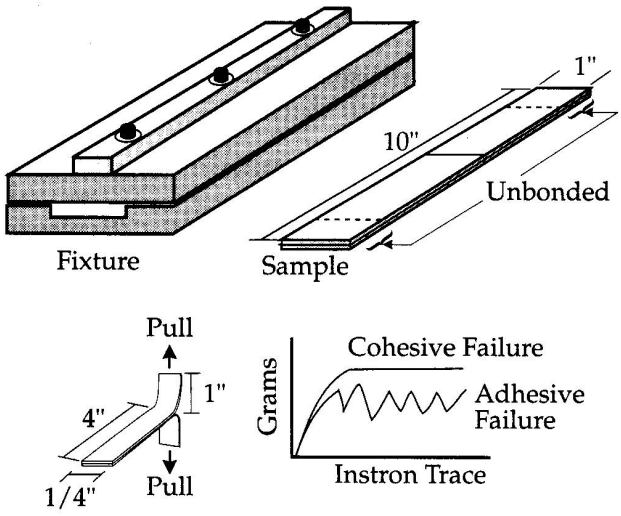

Fig. 3