Tech Tip 15

The Effect of Relative Humidity and Temperature on VR for Room Temperature Curing ECAs

What > The Effect of Relative Humidity and Temperature on Volume Resistivity for Room Temperature Curing ECAs

Why > It could be your environment.

Room Temperature Curing Electrically Conductive Adhesives (RT ECA) are an attractive option for use with substrates and components that cannot withstand typical heat curing conditions (100˚C-150˚C) of traditional ECAs, like our well-known EPO-TEK® H20E, a standard in the industry.

Although room temperature curing ECAs can provide similar performance to heat curing ECAs, there are guidelines that need to be taken into consideration when using these adhesives.

Here are the guidelines:

1. Resin and hardener proportions (mix ratio) should always adhere to the data sheet values. For all types of epoxy, hardener and resin must be mixed exactly as prescribed. Even a slight difference may cause the epoxy properties to change.
(See Tech Tip 11 – Converting Mix Ratio by Weight to Mix Ratio by Volume if needed)

2. Room temperature conditions can vary depending on your geographical location and laboratory and/or manufacturing conditions. It is imperative to maintain a temperature between 23˚C and 27˚C (73˚F – 81˚F). Significant temperature fluctuations can affect the cure time, potentially changing the rate of cross-linking as well as the cross-linking density.

3. Relative Humidity (RH) conditions are especially critical for curing room temperature ECAs to ensure optimal electrical conductivity. This is achieved by maintaining an RH between 40% and 60%.

Why Proper Mix Ratio and Temperature are Required

In order for an ECA to achieve optimal electrical conductivity, it must be well cross-linked. This requires that the material be mixed at the proper ratio of A and B and then maintains the proper ratio during the curing process. For traditional heat-cured systems, this cross-linking occurs fairly rapidly and generally ensures that all of the components stay homogeneously mixed throughout the cure.

Room temp ECAs cross-link much more slowly, allowing more time for the cure to be affected if the correct environmental controls are not in place. As the RT ECA is curing, the lowest surface tension components of the adhesive migrate to the higher surface tension interfaces, the highest being the open air. When this happens in excess, the internal mix ratio of curing agent to epoxy is altered from the proper ratio; therefore the adhesive cannot properly crosslink. It may eventually harden, but it may not have good electrical conductivity and may even increase in resistance if post cured at a higher temperature. Curing temperatures below 23˚C are not recommended as the cross-linking rates will be too slow to allow sufficient cure.

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What is the Mechanism for Preventing Separation and Migration?

Excessive migration of low surface tension components can be impeded by the in-situ formation of a thin amine carbonate barrier layer at the air interface. This effectively lowers the surface tension and stops the migration. Under the right conditions, this barrier layer forms naturally from three components: amine + carbon dioxide + water (amine is in the adhesive, low levels of water vapor and carbon dioxide are in the atmosphere). Finally, proper humidity levels are needed to supply the final component of the equation - water.

What Happens If Temperature and Humidity Guidelines are Not Maintained?

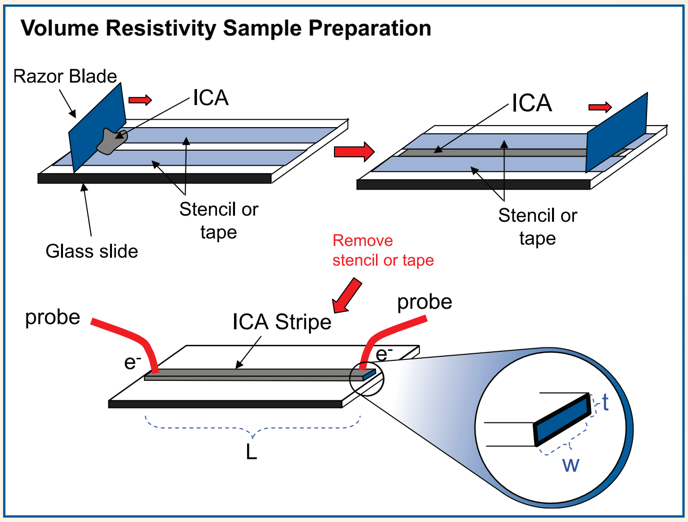
If the temperature and relative humidity levels are not maintained at their recommended ranges, the amine will continue to migrate to the air interface and cause further separation. This will create an imbalance in the unreacted amine functional groups that are available to react with the epoxy functional groups causing a non-homogeneous network that has lost its ability to fully crosslink throughout the full depth of the adhesive. Without the timely formation of amine carbonate (i.e. the in-situ barrier layer), the only other occurrence that could slow the migration is the occasional reaction of an amine group with an epoxy group. This reaction will thicken the adhesive and cause some slowing of the separation, but with long pot life adhesives this happens too slowly to be effective by itself.

***Note:** Post curing an improperly cured RT ECA will not fix the issue and could even drive the electrical resistance up, not down as intended.*

Conclusion:

Maintaining a temperature range of 23˚C to 27˚C and 40% to 60% RH during the full cure cycle of a room temp ECA ensures optimal cure and performance.

How to Measure Volume Resistivity of ECAs



Once the sample has been prepared and cured, the two probes of a voltmeter are applied to the ends of the stripe to measure the resistance across the sample. Volume resistivity is then calculated according to the following equation:

$$\text{Volume Resistivity (ohm·cm)} = \frac{R * w * t}{L}$$

R = resistance (ohms)
w = width (cm)
t = thickness (cm)
L = length (cm)

For other useful tips, contact our Tech Service Group:
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