Frequently asked questions regarding:

TDK's Guide to Multilayer Ceramic Capacitors for Use with Conductive Epoxies

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Abstract

Conductive epoxies use an electrically conductive material mixed with an epoxy resin to create conductive joints used to connect electric components to a PCB. This material serves as an alternative to traditional SMT solder in many applications because of the physical properties of the adhesive. However special care must be taken to make sure the material is used properly during manufacturing.

TDK offers many of our MLCC's with a special termination for use with conductive epoxies.

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TDK Guide to Conductive Epoxy

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Q1. What is an electrically conductive adhesive?

Also called a conductive epoxy, or a conductive glue, it is a material that frequently consists of an epoxy resin mixed with a conductive filler. Higher conductivity can be achieved by using more filler, however, this reduces the strength of the bond due to less adhesive material. These resins require “curing”, or a “setting time”, before the connection is secure.

The conductive material contained in the epoxy is often silver (Ag), or, less frequently, a conductive form of carbon (e.g. graphite).

Q2. Why should I use conductive epoxy?

Conductive epoxies are mainly used in applications where the risks of mechanical and thermal cracking are very high, as well as when there are concerns about damaging heat sensitive components on the PCB during soldering.

Although tin/lead solders have been widely used for many years, leaded solders are becoming much less frequently used because of concerns over lead’s toxicity. Unfortunately, unleaded solders have higher melting points, and because of this, sensitive electrical components near the solder joint can be damaged during the soldering process.

Another issue with lead-free solder is that it is less elastic than leaded solder. This means that lead-free solder joints will be more brittle and more susceptible to developing cracks than with lead-based solder, especially during temperature cycling.

Conductive epoxies are an alternative to leaded and unleaded solders. They have low curing temperatures, reducing the risk that heat sensitive components will be damaged during manufacturing, and they are more resilient to thermal and mechanical stress.

Q3. How does epoxy differ from solder during manufacturing?

The general process for mounting components with conductive epoxy is similar to solder mounting. The following table displays the differences.

Epoxy	Solder
Disperse glue	Disperse solder
Place component	Place component
Cure	Heat/Reflow
Cool (if heated cure)	Cool

Figure 1 Epoxy and solder mounting processes.

The curing durations for epoxies are significantly longer than the heating and cooling times for solders, and care must be taken to make sure they are maintained at the proper temperature during curing, or the epoxy may not fully cure.

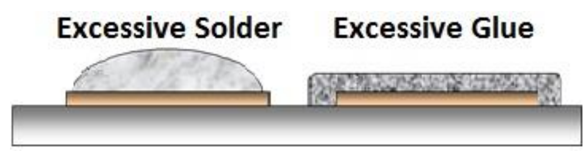


Figure 2 Excessive solder and glue placement.

Conductive epoxies can be made in one or two part systems. One part systems have the advantage of not needing to mix the resins to form the final epoxy. They often have high curing temperatures (150^{0}C), and often need to be refrigerated until used.

Two part epoxies have the advantage of being able to cure at lower temperatures (often room temperature) than single compound epoxies, plus they do not need to be refrigerated. These compounds need to be used immediately after mixing, and can be ruined by an improper mixing ratio of the curing agent.

Special care must be taken when placing the conductive epoxy. In the case of solder, excessive solder can be moved back to the landing point when heated because of the surface tension of the solder. However, epoxies cure without moving, and this can create shorts and silver migration issues (which could eventually result in a short).

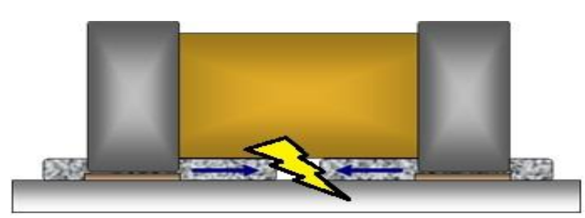
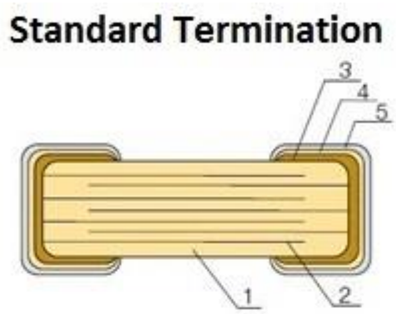


Figure 3 Short risk from excessive glue.

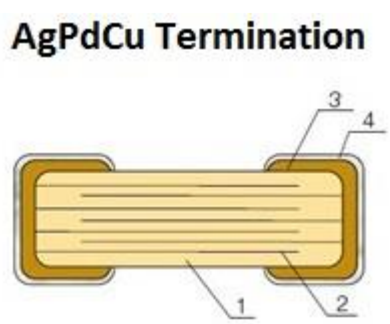
Q4. Does TDK offer MLCCs for use with conductive epoxy?

TDK offers many of our MLCC's with a termination specifically designed for use with conductive adhesives. The termination for use with conductive epoxy uses an outer layer of an alloy consisting of silver (Ag), palladium (Pd), and copper (Cu) on top of a Cu layer. The standard termination of TDK's MLCC's consists of electroplated layers of nickel (Ni), and tin (Sn) on top of a copper layer.



No.	NAME	MATERIAL	
		Class 1	Class 2
(1)	Ceramic Dielectric	$CaZrO_3$	$BaTiO_3$
(2)	Internal Electrode	Nickel (Ni)	
(3)	Termination	Copper (Cu)	
(4)		Nickel (Ni)	
(5)		Tin (Sn)	

Figure 4 Standard MLCC termination.



No.	NAME	MATERIAL	
		Class 1	Class 2
(1)	Ceramic Dielectric	$CaZrO_3$	$BaTiO_3$
(2)	Internal Electrode	Nickel (Ni)	
(3)	Termination	Copper (Cu)	
(4)		AgPdCu	

Figure 5 MLCC termination for use with epoxy.

Q5. Can I use an MLCC with a standard termination with conductive epoxy?

No. The termination used for epoxy mounting serves several purposes.

The addition of copper reduces the silver migration rate of the termination, which increases the amount of time it takes for a short to develop across the capacitor.

The conductive glue can absorb water, which would cause the Sn plating on a standard termination to oxidize. This increases the contact resistance between the MLCC and the conductive epoxy significantly (approximately 100 times greater after 100 hours), which leads to energy losses and heat generation. The AgPdCu alloy does not have the same oxidation issues as Cu/Ni/Sn and maintains a stable contact resistance.

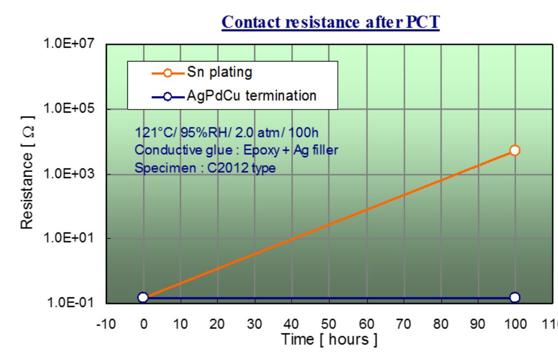


Figure 6 Contact resistance over time.

Finally, during operation, temperature cycling can result in micro-cracks developing between the standard Cu/Ni/Sn termination and the epoxy, resulting in drastic reduction in shear force required to remove the chip from the board. The AgPdCu termination reduces the rate at which these micro-cracks develop because the silver contained in the termination and the conductive adhesive have a strong affinity for each other.

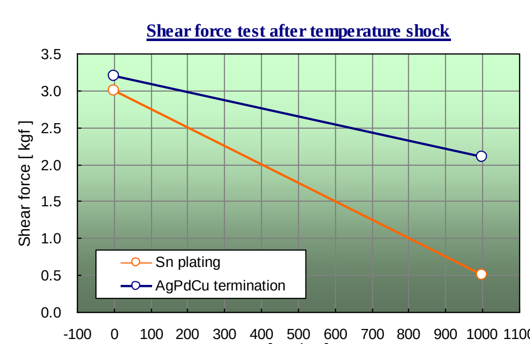


Figure 7 Shear force after temperature cycles.

Q6. What is the Difference Between "Soft Termination" and "Conductive Epoxy Termination"?

TDK's Soft Termination series is an MLCC with a layer of conductive resin built in to the standard termination.

The Conductive Epoxy series uses an AgPdCu termination for use with conductive epoxy as a mounting adhesive (solder replacement).

Both series allow for greater resistance to cracking due to mechanical stress, and significantly more resistance to cracking due to thermal shock. Additionally, the low curing temperatures of the conductive epoxy series preserve heat sensitive components during manufacturing.

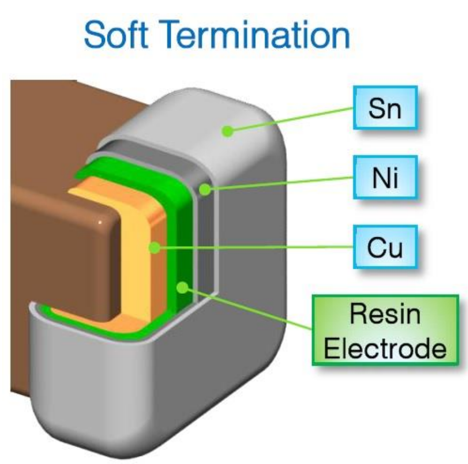


Figure 8 MLCC with soft termination.

Q7. What type of epoxy should I use?

Because epoxy technology is so mature, many companies can engineer a variety of compounds for an even greater variety of specifications. Conductive epoxies can be modified and manufactured to meet many different performance characteristics and specifications including cohesive strength, hardness, durability, flexibility, temperature resistance, viscosity, thermal conductivity, electrical conductivity, moisture resistance, chemical resistance, resistance to mechanical shock and vibration, as well as the ability to withstand ultra-high or cryogenic temperatures.

As with all engineering, there are trade-offs for every type of epoxy. For example, epoxies with higher conductivity have a weaker bond strength because of the greater filler to resin ratio. Thorough research of the advantages and disadvantages of each type of epoxy should be conducted in order to ensure the epoxy will meet the required specifications.

End of Report

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