Terminal Adhesion

Frequently asked questions regarding the
MLCC-to-PCB bond after reflow soldering.

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Abstract
MLCC users continue to minimize solder amounts in the SMT process to the point components "fall off the board" in some cases. This paper provides an explanation of MLCC terminal adhesion in a question and answer format readers find most helpful.

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Question 1: What can cause SMT capacitors to come off the PCB after soldering?
Any number of things can cause this problem, however the most common are solder joint quality and harsh handing. Solder joint quality here means the solder fillet volume and its coverage on the component's termination.

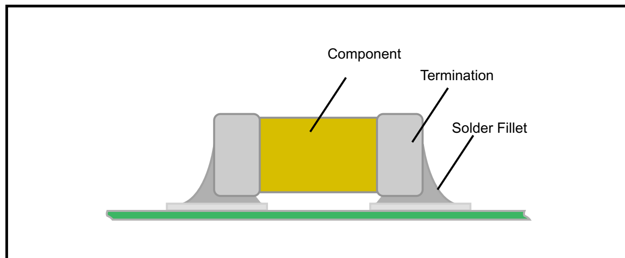


Figure 1: Side view of soldered component

The adhesion between the component and the PCB is directly proportional to the amount of solder used in most cases.

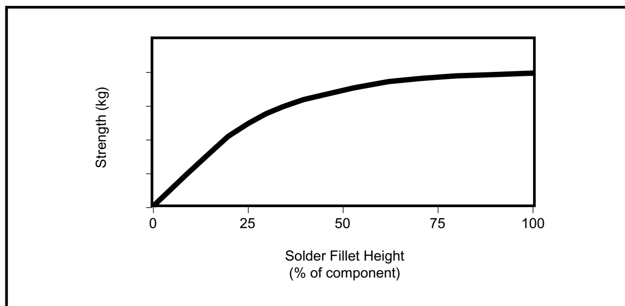


Figure 2: Terminal adhesion increases with solder amount

Solder fillets typically become smaller as the component becomes smaller, and the lack of solder mass will reduce the adhesion strength also.

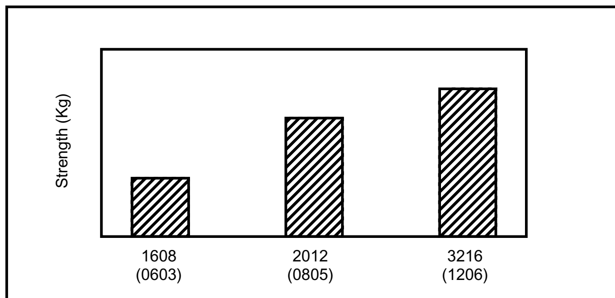


Figure 3: Adhesion strength increases with solder amount and case size

Abusive handling obviously can cause the capacitors to come off after soldering, but even normal handling can dislodge a component from the PCB with small solder fillets. Touching the populated PCB with the hand or instrument should be a point of training and minimized as much as possible. Also, aqueous washes offer use higher water pressure than necessary when cleaning flux from the board. Brushes, conveyors, and robotics are all areas of handling risk.

Question 2: What is "terminal adhesion"?
Terminal adhesion is the amount of force required to remove a component's termination from its body. It is most often evaluated by an axial lead pull or side push test. It is typically expressed in kilograms and is dependent upon component case size.

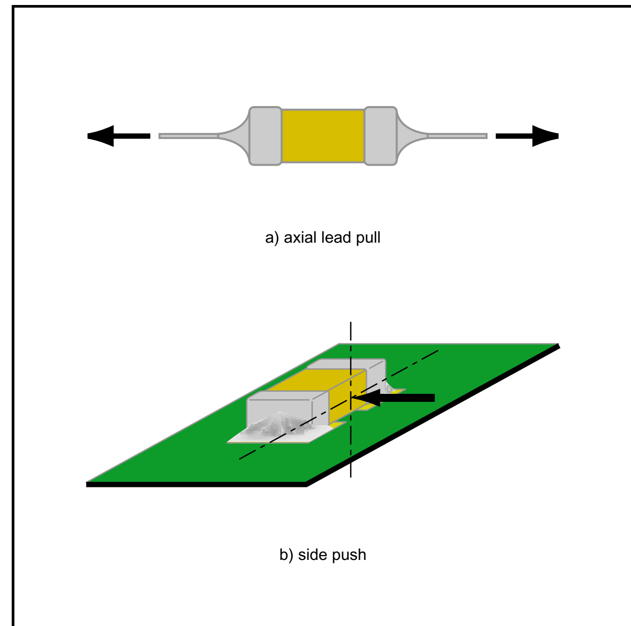


Figure 4: Traditional terminal adhesion tests

The axial lead pull[1] is the best measure of a component s true terminal strength, but the side push method takes into consideration the SMT process as a whole. *Note: The side push method is heavily dependent upon solder amount and the push point on the component.*

The magnitude of terminal adhesion should always be discussed together with the failure mode. The

three basic modes of failure are illustrated below.

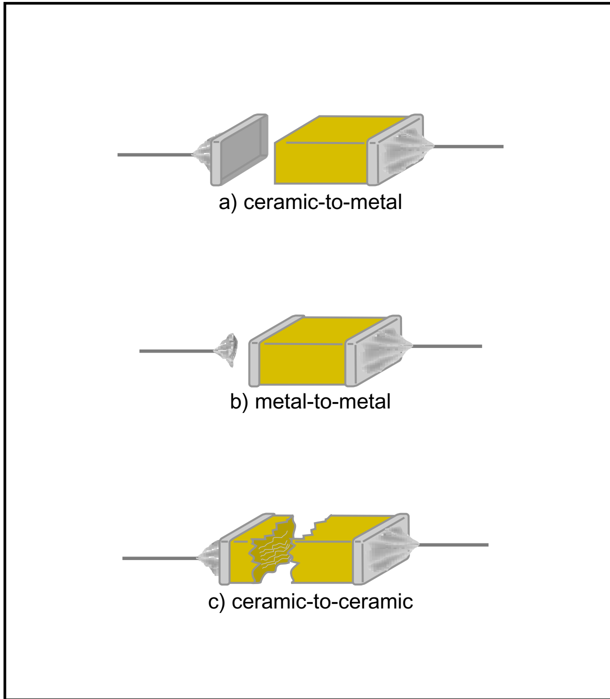


Figure 4A: Failure modes, lead pull

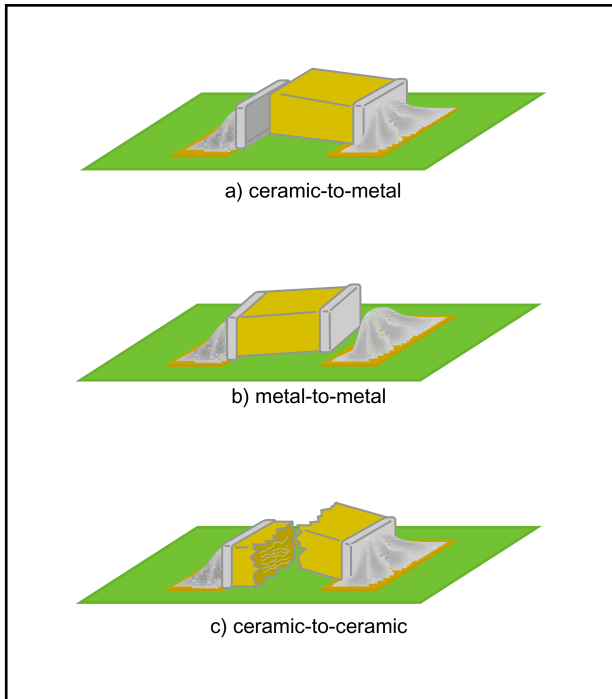


Figure 4B: Failure modes, side push

The failure mode can change with varied solder fillet heights. A ceramic-to-ceramic or metal-to-metal failure mode typically yields the highest strengths and is therefore generally preferred.

Question 3: What is the proper amount of solder?

The solder fillet is most practically expressed in terms of coverage of the component's height or thickness.

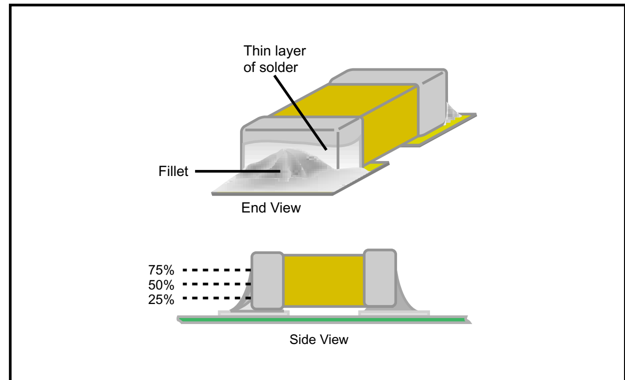


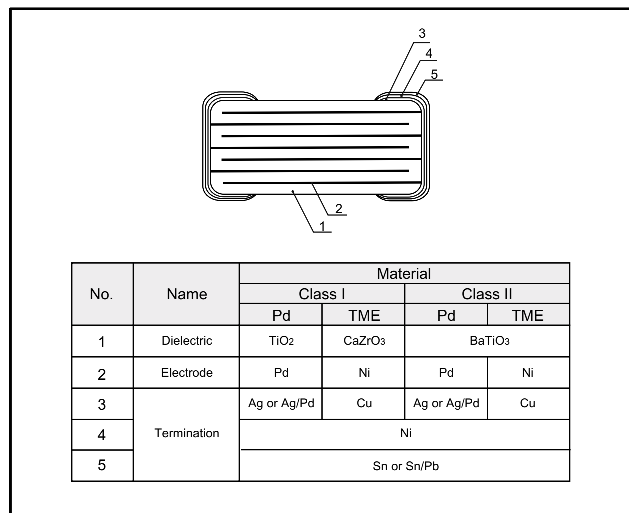
Figure 5: Solder fillet [2]

TDK recommends the solder fillet to be ≥50% of the MLCC thickness. Additionally a thin layer of solder typically extends beyond the fillet's bulbous volume, indicating the termination was properly "wet" by the solder and therefore exhibits good solderability. EIA[3] recommends ≥25% of the component thickness.

Note: Often manufactures will try to minimize the amount of solder used for cost control or tombstone prevention, however great care must be used to avoid sacrificing adequate solder fillets and proper terminal adhesion.

Question 4: What MLCC variables effect terminal adhesion?

Solderability and plating thickness[4] play an important role in terminal adhesion, however it is the MLCC s material system that is most significant.



No.	Name	Material			
		Class I		Class II	
		Pd	TME	Pd	TME
1	Dielectric	TiO_2	$CaZrO_3$	$BaTiO_3$	
2	Electrode	Pd	Ni	Pd	Ni
3	Termination	Ag or Ag/Pd	Cu	Ag or Ag/Pd	Cu
4		Ni			
5		Sn or Sn/Pb			

Figure 6: MLCC Inner Structure

The material system used in a ceramic capacitor is rather complex, especially when considering the bond between the ceramic dielectric and the metal electrodes. The type and amount of glass frit used in the termination paste as well as the ceramic dielectric formulation are key variables for terminal adhesion. The co-firing temperature profile and atmosphere provide the catalyst for the termination-ceramic bond to occur.

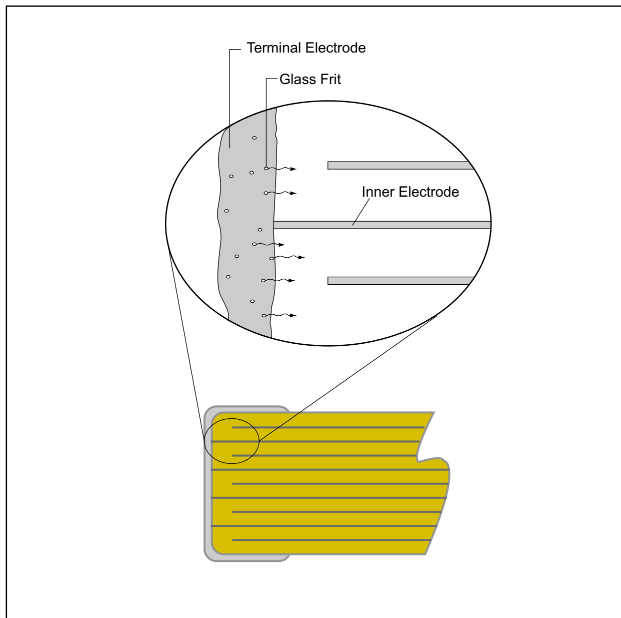


Figure 7: Glass frit penetrates the ceramic dielectric

Question 5: What should the end-user do to ensure good terminal adhesion?
By far the most common problem associated with poor terminal adhesion is too small of a solder fillet. Properly sized stencil apertures and a printing process free of "blinding" are crucial. Avoiding too fast of a solder profile will help ensure good solder flow and provide proper solder coverage.

Contaminated solder lands could effect the adhesion between the solder fillet and the PCB. Only clean PCB's (free of oils, moisture-free, etc.) should be used to ensure good terminal adhesion.

References:
[1]EIA-198-2-E, method 303, "Terminal Strength".
[2]TDK Multilayer Ceramic Chip Capacitors. Application Manual, Sept 1988 (publication BBE-017A).
[3]ANSI/J-STD-001B, Oct 1996.
[4]C.F.Smith, Jr., "End Termination Compositions for Multilayer Chip Capacitor: Platable Bases and Plating", 37th Electronics Components Conference, 1986.

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End of Report

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