Tech Topic

Flex Crack Mitigation

KEY TOPICS

Flexible Termination, Floating Electrode, Open Mode

INTRODUCTION

As part of continuous process improvement at KEMET, most failure modes caused by the capacitor manufacturing process have been systematically eliminated. Today these capacitor manufacturing-related defects are now at a parts per-billion (PPB) level. Pareto analysis of customer complaints indicates that the #1 failure mode is insulation resistance failure due to flex cracks.

FLEX CRACKS

Flex cracks have been known in PCB manufacturing for quite some time. Flex cracks are created in capacitors when board flex stress / bending stress is applied to a circuit board with ceramic components already affixed to the PCB. As the ceramic capacitor is inherently hard, non-elastic, and brittle (relative to the PCB), any bending of the board creates stress, and that stress can be transmitted through the solder joint, directly to the ceramic body. This stress must be relieved somehow – and this stress relief can result in the creation of a board flex crack (See Figure 1).

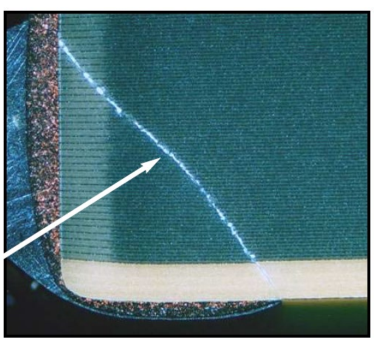

Figure 1 – Typical Flex Crack

In PCB assembly, some of the sources of this stress include the following:

- Connector Assembly/Connector Use – MLCC's placed close to connectors are particularly susceptible to board flex stress (See Figure 2).
- Depanelization – where many small boards are assembled as one large panel that must then be separated, especially when MLCC's are located close to the edge of the PCB (See Figure 3).

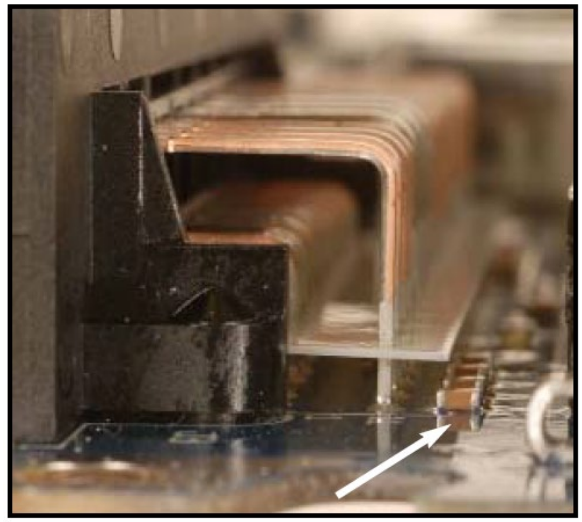

Figure 2 – Filter capacitor very near to thru-hole connector.

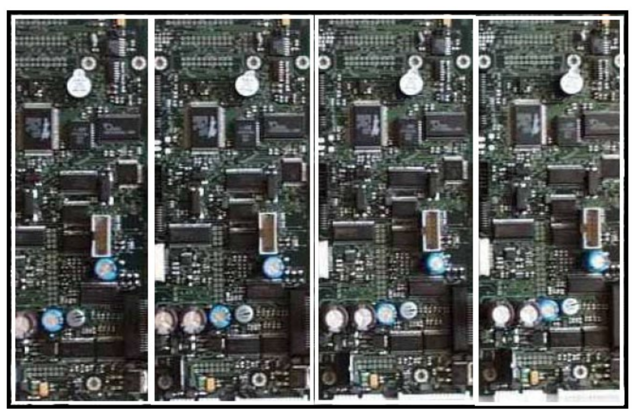

Figure 3 – Board singulation can flex stress ceramic capacitors near board edge.

- Box build – assembly of a final product can involve stresses as boards are fitted together – particularly given the demands for today's thinner product offerings.

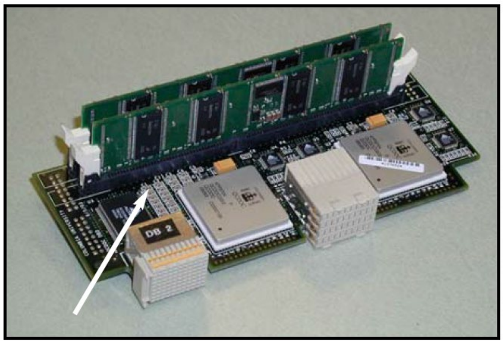

Figure 4 – Parts located near connectors can be susceptible to board flex stress.

PCB assembly continues to evolve, and by carefully understanding and controlling the board assembly process, the occurrence of board flex stress can be reduced. However, these board flex stresses have not been eliminated – and in many cases the worst-case scenario is a resultant short circuit which leads to field failure. KEMET now offers a portfolio of engineered solutions to mitigate the effects of board flex stress. By creating solutions that lend themselves to open failure mode rather than short circuit failure mode, KEMET is offering a measure of protection for customers who know that short circuit failure is not an option.

FAQ's AND DEFINITIONS

The following statements are based on extensive industry research, whitepapers, and presentations. All of these questions are answered assuming the customer is using a standard, 2-terminal MLCC.

1. Does a flex crack always lead to failure?
   Answer – no; as with all cracks in MLCC's, there needs to be some type of ionic penetration or humidity along the crack path which allows current to flow between electrode plates of opposite polarity, in order for the chip to fail. (See Figure 5).

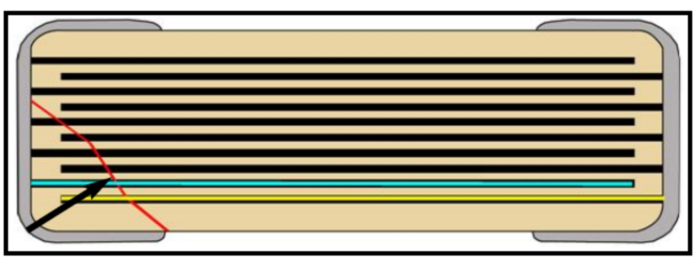

Figure 5 – Yellow electrode represents (+); blue electrode represents (-); flex crack leads to short circuit

2. Does a Flex Crack always have the same crack signature?
   Answer – yes. There is a distinctive crack signature for board flex cracks – it always starts near the edge of the termination margin, and usually extends upwards toward the termination face. The flex crack signature is distinctly different than other crack signatures in MLCC's. (See Figure 6)

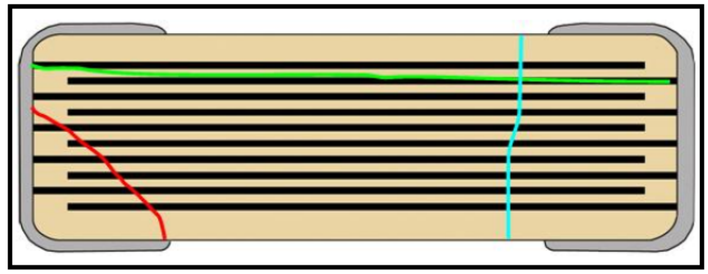

Figure 6 –Red crack represents flex crack; green crack represents typical thermal shock crack; blue crack represents mechanical damage.

3. Are there PCB assembly process parameters that can be modified to reduce the risk of board flex cracks?
   Answer – yes. Studies have shown that by minimizing the amount of solder (size of solder fillet),and minimizing chip size (smaller chips are inherently more robust than larger chips), the chances of failure due to board flex cracking can be reduced.
4. Are there ways to place parts away from "problem areas" on the PCB?
   Answer – yes. By placing parts parallel to the edge of the PCB, as far away from the edge of the PCB as practical, and as far away from thru-hole connectors/screws/etc., manufacturers can reduce their risk of MLCC board flex cracks.
5. Does KEMET ever ship capacitors with flex cracks, while still in the tape & reel?
   Answer –no, flex cracks can only occur post solder attach.

KEMET SOLUTIONS

If board flex stress cannot be eliminated, there are several options available that offer methods to mitigate the risk associated with board flex cracks. In order to offer a cost-effective solution, there are several options available, based on the capacitance value selected.

- For **lower** capacitance values, KEMET offers the Floating Electrode (FE-CAP) design. This is also known in the industry as a Serial Cap design, as the Floating Electrode part contains two parts in series, within a singular capacitor body. In Automotive (Clamp 30) designs, sometimes 2 distinct capacitors will be used in series on the PCB – the FE-CAP gives a designer this "two parts in series" - within a singular capacitor. This solution works by eliminating the short-circuit path between electrodes of opposite polarity (See Figure 7).

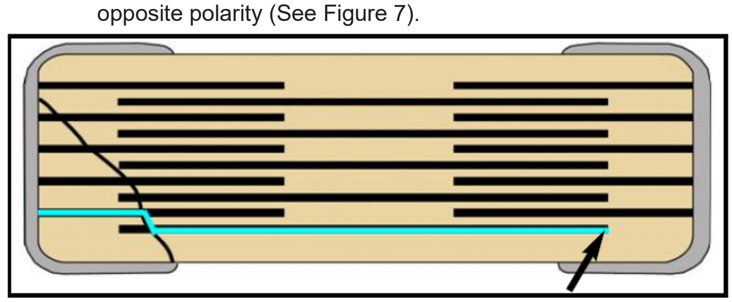

Figure 7 – Flex crack does not complete circuit - no short circuit failure.

Due to the sacrifice of active area necessitated by the creation of two serial capacitors, the Floating Electrode solution can only be used for lower capacitance values. To order this device, simply place an S for "Serial Cap" in the 6th digit of the KEMET part number. For customers desiring an additional mode of protection, KEMET offers the FF-CAP (Floating Electrode + Flexible Termination – see Flexible Termination description later in this paper). To order this device, place a "Y" in the 6th digit of the KEMET part number.

- For **mid** capacitance values, KEMET offers the Open Mode solution. The Open Mode device creates a safe zone on both ends of the capacitor (See Figure 8), so that only the innermost portion of the capacitor is active area. Any board flex crack that occurs (remember, this crack always starts within the end termination) can only cross electrodes of like polarity; thus eliminating the possibility of a short-circuit failure from a board flex crack. As with the FE-CAP, active area has been sacrificed in order to create the safe zones on both ends of the chip; thus, the Open Mode solution is only applicable for mid capacitance values. To order this device, place an "F" for "Fail Open" in the 6th digit of the KEMET part number. Open Mode can be ordered with Flexible Termination by changing the 6th digit of the KEMET Part Number to a "J".

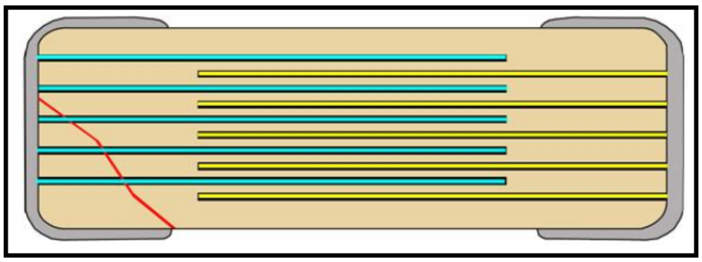

Figure 8 – Blue represents (-), Yellow represents (+), flex crack only crosses electrode of like polarity.

- Finally, for **high** capacitance values (also called HiCV in the industry), KEMET offers the Flexible Termination (FT-CAP). KEMET applies a special conductive silver epoxy on both end terminations, between the copper/electrode interface and the nickel/tin plating. This special epoxy layer is essentially a tearaway solution, providing a path of least resistance for board flex stress. This solution acts to steer the potential flex crack away from the ceramic body, into the more benign area of the termination (See Figure 9). Technically, Flexible Termination can be applied to any commercial SMD (Surface Mount) product, but due to additional manufacturing costs (primarily materials and labor), the Flexible Termination is more cost effective when used on HiCV devices. KEMET's Flexible Termination offers up to 5mm of board bend stress capability. To order this device, place an X for "Flexible Termination" in the 6th digit of the KEMET part number.

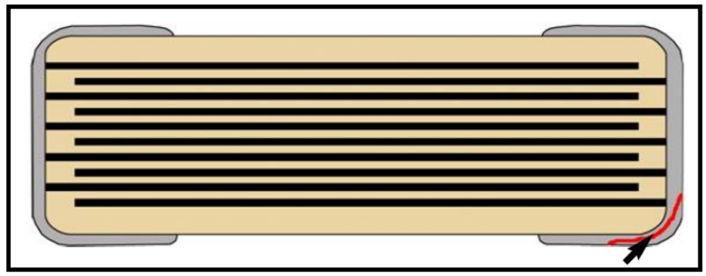

Figure 9 –Flexible termination moves flex cracks to the end termination, away from the ceramic body.

AVAILABILITY

All solutions mentioned above are available today from KEMET. As Automotive is a primary market focus for these Flex Crack solutions, KEMET has qualified all of the solutions per AEC-Q200 (documentation available upon request). For more specific information, including available capacitance values, sample requests, datasheets, etc., please visit our website: https://www.kemet.com/

CONCLUSION

Board flex cracks have been around since the inception of SMT processing, and still represent a significant headache as measured by customer complaints, field failures, etc. By selecting an appropriate board flex mitigation product, designers now have an option when board flex stresses cannot be eliminated from the PCB manufacturing process.

REFERENCES

"Capacitance Monitoring While Flex Testing", 1997, Jim Bergenthal and John D. Prymak, F-2110, KEMET Electronics Corporation

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