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Fractured MIL-PRF-55342 Resistors

MIL-PRF-55342 resistors are built on 96% (thick film) or 99.6% (thin film) alumina substrates. These substrate materials dominate the mechanical properties of the resistor. These ceramic substrates are hard and strong but they are also brittle. Our substrate supplier reports flexural strengths (ASTM-F394) of 58 kpsi and 86 kpsi for these substrates used to build thick and thin film resistors. These devices do not break easily. Broken resistors on circuit boards have been found to result from a hand soldering processes gone awry, an impact event, or board flexure of conformally coated product. Broken resistors occur in hand soldering processes where one end Is soldered in place leaving the other end tombstoned. A broken resistor results from the operator's attempt to correct the tombstone condition (Figure 1). Resistors are also broken when they sustain an impact event such as a tool being dropped on the device (Figure 2). Resistors fractured prior to the application of conformal coat will often have conformal coat material on the fracture surface.

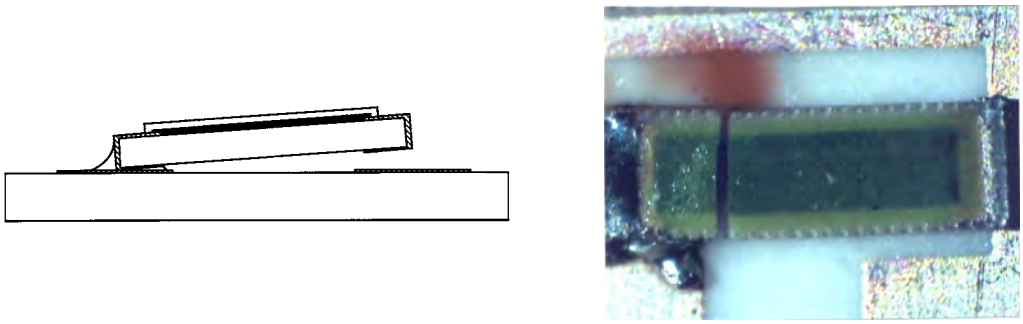


Figure 1. A diagram of a tombstoned resistor and a fractured RM1505 resistor after having force applied to the tombstoned end (2.8 to 5.1 kg force).

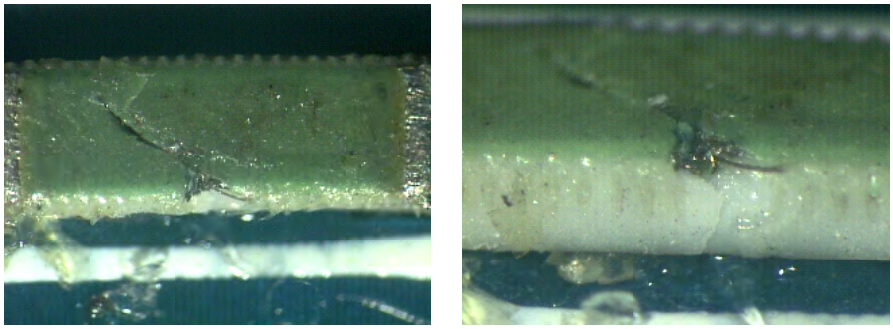


Figure 2. A broken RM1505 damaged by an impact event.

Several customers have reported broken MIL-PRF-55342 resistors on circuit boards with conformal coat. The devices are often broken midline but we have seen the fractures deviate ±30% of the case length from the midline. The fracture surfaces are free of any conformal coat material indicating the devices are broken after the boards are coated (Figure 3). Resistors with conformal coat break when the board is flexed. Performing board flexure on uncoated devices results in deformed or cracked solder fillets (Figure 4) but does not fracture the resistor.

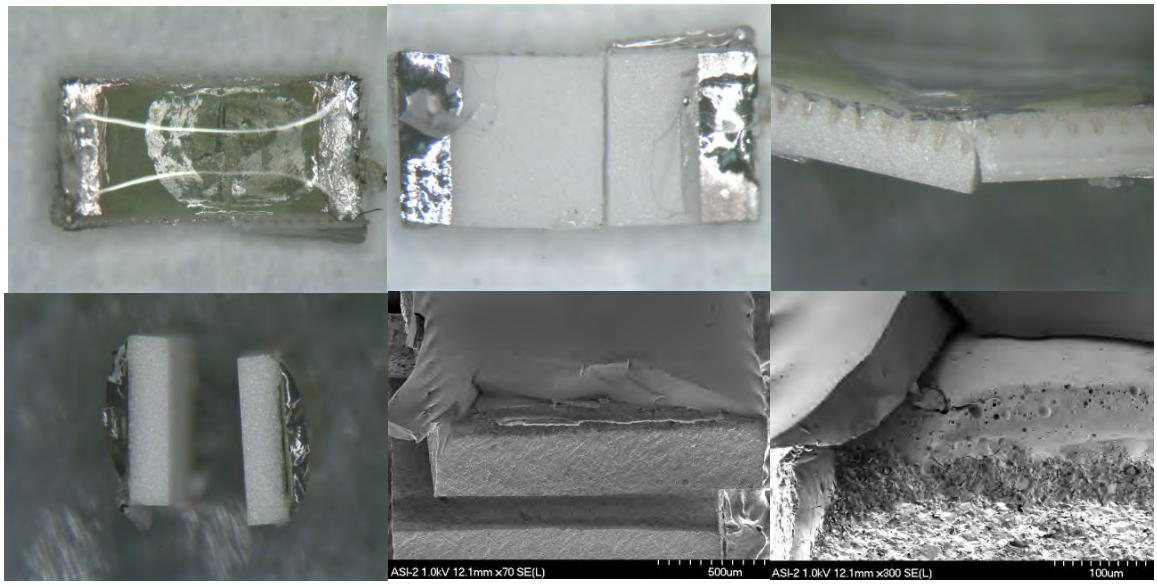


Figure 3. A broken, coated RM1206 thick film device. SEM analysis found no conformal coat material on the fracture surfaces.

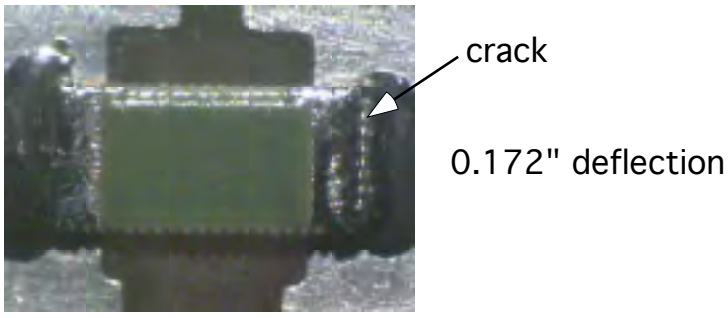
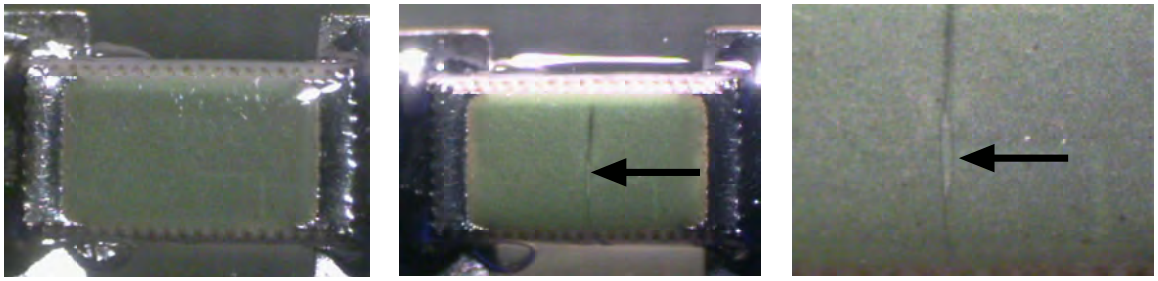


Figure 4. A RM1206 thick film device mounted on FR4 board showing the resistor to be undamaged and a damaged solder fillet after convex flexure.

Conformal coat materials used on boards with broken resistors include Uralane 5750, Tech Spray UR, and Hysol PC18M. Electrical anomalies were identified during board and box level screening such as vibration testing, temperature cycling, etc. Some broken resistors have been traced to rework operations that resulted in board flexure.

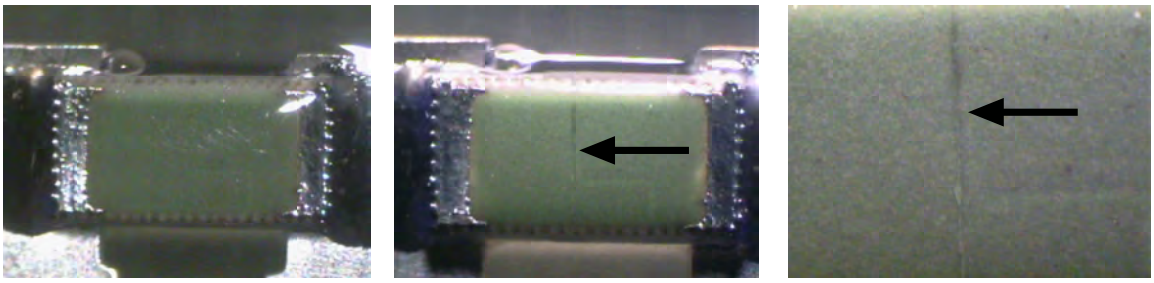
Other broken devices have been attributed to excessive board flexure during vibration testing. We have seen broken RM1505, RM1206, and RM0603 devices.

The appearance of the glass passivation material on the resistor provides clues indicating the direction of the flexure. The passivation material adjacent to the fracture is often spalled when the device is on the concave surface (Figure 5). Conversely, no spalling is evident when the device is located on the convex surface (Figure 6). The presence of conformal coat material changes the stress developed during a flexure event. The conformal coat pins the resistor and does not allow the solder fillet to deform during the flexure. The stress builds in the resistor until it fractures.



before test | after flexure | higher mag.

Figure 5. A coated, RM1206 resistor with spalling in the glass passivation adjacent to the fracture exposed to concave flexure.



before test | after flexure | higher mag.

Figure 6. A coated, RM1206 resistor with a fracture but no spalling of the glass passivation exposed to convex flexure.