Cracked Solder Joint: WHAT IS YOUR LEAD DEPTH ON LEADED SURFACE MOUNT COMPONENTS?

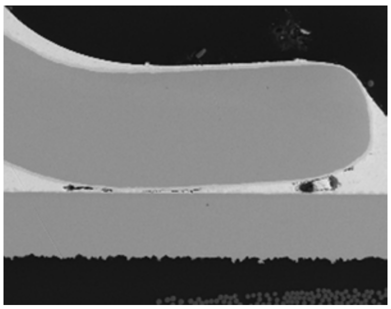
By: Mark McMeen

Everyone inspects solder fillet formation on leaded surface mount devices from the topside looking for good wetting to the lead and heel. Typically, most inspection is performed to industry standards (i.e., IPC A-610C). These are all valid and necessary inspection criteria that are used to ensure that solder connections are formed correctly and meet the requirements for long-term reliability. What is not readily visible is sometimes overlooked and assumed to be good. This may not always be the case in some consumer and industrial electronic assemblies. High thermal and mechanical shock environments sometimes reveal unseen processing related failures within a solder connection. One such phenomenon, as shown on the following page, is a cracked solder connection that creates an open circuit. How can this be, you might ask? What is not readily visible is the z-axis lead position within the solder fillet. One assumes everything is acceptable from topside visual inspection. Components that are surface mounted and have a lead frame are susceptible to variations in the z-axis position within the solder fillet. This condition is prevalent in consumer and industrial circuit card applications where the operating environment introduces thermal extremes on the solder connection and/or mechanical shock forces from dropping the end product. Additionally, leaded surface mount components are susceptible to cracked solder fillets because there is insufficient bulk solder between the lead and the printed circuit board pad surface. This is why one must have process controls on their pick-n-place machines, specifically the placing stroke setting that controls insertion depth into the solder paste. Most pick-n-place machines default to a zero z-axis height, which equates to placing the component through the paste depth to the surface of the board.

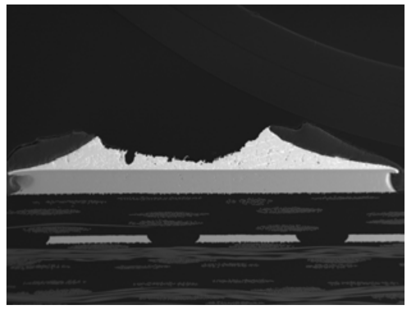
In most applications this is acceptable except where the environment creates coefficient of thermal expansion issues (CTE movement) due to thermal excursions. In a mechanical shock environment, high shock forces are introduced when the consumer drops his finished product. These environments introduce applied stresses into the solder joint and, if micro-fractures or voids are present underneath the solder connection, they can propagate into a fully cracked solder connection.

The following examples show the effects of placing components on the surface of the printed circuit board pad with little or no bulk solder region between the lead and the pad surface. Take special notice of the micro-fracturing and voiding that occurs when the tin and the copper form an intermetallic on the lead and on the printed circuit board pad surface. The region between the lead and pad surface now has no bulk solder to allow for CTE expansion and contraction causing localization of stress across the tin/copper intermetallic area. The tin/copper intermetallic is very brittle and has very low lateral strength across the attachment surface between the bottom of the lead and top of the printed circuit board pad.

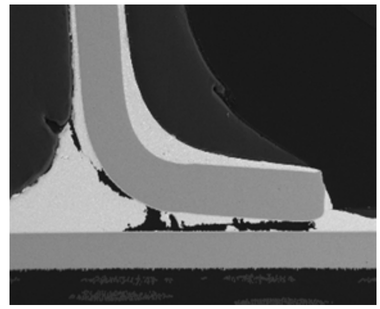
The following examples show good and bad solder fillets with respect to lead depth in the solder joint.



(1) Partially Fractured Lead



(2) Leaded Device has Fallen Off the PCB



(3) Completely Fractured Lead

The examples demonstrate the potential problem when there is minimal or no bulk solder region present between the component lead and the topside of the printed circuit board pad. The effect of voiding and micro-fracturing along the bottom side of the lead is worsened by placing component leads too deep into the solder paste. The solution, as mentioned previously, lies in adjusting the placing stroke setting to ensure component leads are not placed to the zero z-axis line on the machine. The most common observation of this error is that the placing stroke setting on the pick-n-place unit is at zero or a positive number in the z-axis. This means the nozzle is placing the component down to or past the zero axis level or surface on the printed circuit board. Placing past the zero axis level is possible since most nozzles have some spring back effect to their nozzle configuration.

So, check your lead depth. Ensure you have a safe bulk solder region between your lead and printed circuit board pad surface. This will help you avoid the problem of cracked solder connections.

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