By Ray DiBugnara

Soldering Guidelines for Glass MELF Diodes

The following is provided for soldering glass body surface mount diode products to PC boards. These are often identified as MELF diodes for "Metalized Electrode Leadless Face". They are typically represented in three categories as described below using a double slug design to make contact to an active die element inside a glass envelope body with round or square end caps for external contact and solder mounting. These packages have their own considerations for solder mounting with the materials described below.

Glass diodes fall into three categories:

1) Dumet slug and Dumet sealing glass. Dumet is a 42% nickel-iron core material with a copper sheath. The copper sides of the slug have a special copper sealing oxide to attach the glass. The ends of the slug have a copper smear coating suitable for bonding. Sealing temperatures are typically around 650°C where the die bond occurs simultaneously. Mechanical characteristics of Dumet are:

a) TCE 9.0 PPM/C radially (due to copper sheath) and 7.1 PPM/°C axially
b) YTS 50000 PSI (annealed)
c) Young's Modulus 2.10E7 PSI (annealed)
d) Silicon chip TCE 3.5 PPM/°C (average) must be combined with other metal layers to raise the overall TCE to match the axial TCE of the Dumet.
e) Glass TCE matches Dumet radially at 9.1 PPM/°C.
Glass YTS is 7000 PSI and Young's Modulus is 7.5E6 PSI.
f) MELF end tabs are made of Dumet formed simultaneously with the formation of the slugs themselves and naturally have the same TCE of 7.1 PPM/°C axially.

2) Tungsten slug and tungsten sealing glass. The slug is pure tungsten and typically has a nickel-silver plating which is suitable both for glass sealing and high temperature die bonding. Die bonding can occur simultaneously with sealing but often we accomplish the die bond first at higher temperatures prior to the glass seal. Mechanical characteristics of Tungsten are:

a) TCE 4.43 PPM/°C in all directions
b) YTS 140000 PSI (annealed)
c) Young's Modulus 5.80E7 PSI (annealed)
d) Silicon chip TCE 3.5 PPM/°C (average) is close enough to tungsten that the bonding metals alone are sufficient match to the package.
e) Glass TCE matches tungsten in all directions at about 4.5 PPM/°C.
YTS for the glass is 7000 PSI and Young's Modulus is 8.65E6 PSI.
f) MELF end tabs are made of copper brazed to the silver plated slug after the manufacture of the diode glass body. The CTE for copper is 16.6 PPM/°C.
Young's Modulus for annealed copper is 1.6E7 PSI and YTS is 35,000 PSI.

3) Molybdenum slug and molybdenum sealing glass. The slug is pure molybdenum and typically has a nickel-silver plating which is suitable both for glass sealing and high temperature die bonding. Die bonding can occur simultaneously with sealing but often we accomplish the die bond first at higher temperatures prior to the glass seal. Mechanical characteristics of Molybdenum are:
   a) TCE 5.22 PPM/°C in all directions
   b) YTS 120000 PSI (annealed)
   c) Young's Modulus 4.70E7 PSI (annealed)
   d) Silicon chip TCE 3.5 PPM/°C (average) is close enough to molybdenum that the bonding metals alone are sufficient match to the package.
   e) Glass TCE matches molybdenum in all directions at about 5.2 PPM/°C. YTS for the glass is 7000 PSI and Young's Modulus is 9E6 PSI.
   f) MELF end tabs are made of copper brazed to the silver plated slug after the manufacture of the diode glass body. The CTE for copper is 16.6 PPM/°C. Young's Modulus for annealed copper is 1.6E7 PSI and YTS is 35,000 PSI.

When soldering glass diodes onto printed circuit boards, leaded axial glass products are capable of sustaining substantial mechanical abuse due to the flexibility of their leads. That leaves the MELF package as the main focus of this document.

Solder Mount Guidelines

Glass packages can tolerate high temperatures up to 350°C (below the glass transition point) but do no appreciate sudden temperature change. Because the MELF has heavy tabs on each end, very rapid conduction of heat is possible into the package. If heat is applied too quickly, stress or damage to the glass or the silicon chip is possible. Fortunately this can be avoided by taking the following precautions:

1) General: Remember that you are soldering a rigid glass diode to a rigid printed circuit board. The closer the PC board TCE comes to the package overall TCE, the better. Since some mismatch is unavoidable, the solder must be relied upon to take up the slack.

2) Wave Soldering: Here, the part is pre-attached with a quick drying adhesive. Since these are glass devices, the adhesive should not be rigid but should have a little give since the TCE of many adhesives are very high. The solder wave should never be allowed to flow on the glass diodes without some pre-heating. This warming stage should be around 150°C or, if possible, a modest temperature ramp-up which crosses through the 150°C range. The solder wave temperature is typically around 230°C to 245°C but can be as high at 260°C. Since both board and glass diode are heated together, the glass diode is likely to come under some compression as everything cools since most boards will have a TCE higher than 10 PPM/°C. Glass diodes are usually stronger in compression than in tension.

3) Solder-Paste Re-flow: Here the part is tacked to the board using a dispensed solder paste. This method is desirable because no adhesive is required and fairly potent no-clean flux-paste combinations are available. Also, since the heating is done by infrared or hot nitrogen, the heating is more gradual and gentle. The solder pad size and shape, however, must be controlled so that solder surface tension does not move the component during re-flow. As with the wave solder technique, the board is heated up with the glass diodes and cooling leads to some compression of the diode. Again, glass diodes are usually stronger in compression than in tension.

4) Soldering Iron: The use of a soldering iron generally causes no problem for axial leaded components. The leads have enough flex in them and they are thin enough to prevent excessively rapid heat transfer to the diode. Usually with a soldering iron, however, the PC board does not heat up as hot as a surface mount diode. Hence, when during cooling solidus is reached (183°C for Pb63Sn), the diode comes under tension rather than compression. However, even worse, the soldering iron itself supplies a tremendous inrush of heat into the glass diode. This is exacerbated when the soldering iron has a heavy tip and is controlled above 600F sometimes to temperatures as high as 800°F to speed up the process. The diode is unable to achieve thermal equilibrium fast enough and internal stress can occur, compressive during heat up followed by tensile during cooling. The easiest solution is to provide a jet of hot gas (usually nitrogen) to pre-heat the diode and the local PC board area. This permits the iron to be as low as 500°F and still do a rapid solder job. It has been speculated that a soldering iron with a thin cross section iron rather than a broad cross section copper tip might have a built-in slow heating capability.
5) Conformal coating: Protection of PCB mounted components with a conformal coating is a widespread practice. Usually soft materials are selected so that the flexibility of the material does not present any undo stress on the components. However, many of these so-called “flexible” compounds become very rigid at low temperatures. If the conformal coating is applied in a very thick layer, the build-up of material under the mounted MELF diode, because its CTE is so much higher than the MELF itself, can exhibit a “heaving” effect under the diode over multiple temperature cycles possibly causing failure of the glass or glass seal. Remedy for this is thin conformal coats. Where thin coats are not possible, a small local application of a silicone rubber to fill the space between the diode and the PCB can alleviate the situation. For most Users, however, reverting to a thinner conformal coat is sufficient to prevent any problems.

Summary

Tungsten, molybdenum and Dumet seal axial diodes do not present any problem with solder mount onto printed circuit boards.

MELF diodes, when enjoying a preheat prior to soldering, likewise should not present any problem. Soldering iron solder-shock processes, however, need to be paid attention to.

Keep conformal coatings as thin as possible when very low temperature operation is needed.