V. Plastic Package

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Studies have shown that during the high-temperature soldering process encountered while mounting packaged semiconductor devices on circuit boards, moisture present in a plastic package can vaporize and exert stress on the package. This stress causes the package to crack and also causes delamination between the mold compound and the lead frame or die. These effects are most pronounced if the package has greater than 0.23% absorbed moisture before solder reflow [1]. Figure 9-15 shows a typical example of a package crack. The mismatch in thermal expansion coefficients of package's components also induces stresses. If these combined stresses are greater than the fracture strength of the plastic, cracks will develop. The cracks can provide a path for ionic contaminants to reach the die surface, and die delamination can cause wire-bond failure. Hence, these are reliability concerns.

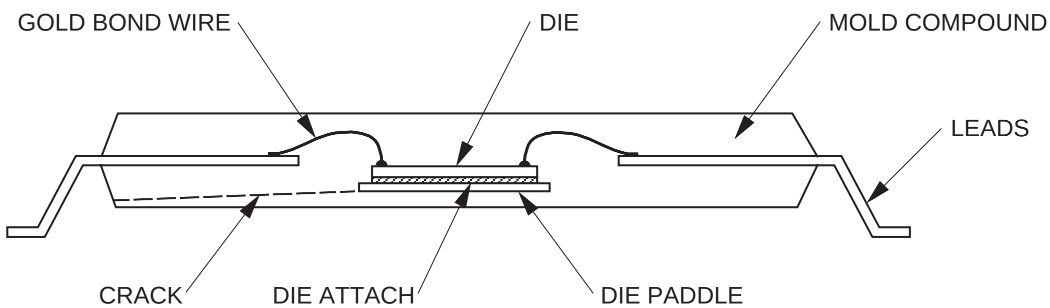

Figure 9-15. Typical plastic package showing the onset of a crack.

The following recommendations will ensure minimal package damage from moisture [2]:

(1) Complete board assembly 1 week after removal of the components from their dry packs, if the environmental conditions do not exceed 30°C and 60% RH.

(2) After 1 week, bake for a minimum of 12 h at 115°C; this will gradually drive out the moisture.

To overcome the delamination problem, results derived from numerical simulation and experimental data can serve as a guide in the selection of suitable molding compound properties [3]. The properties considered are the adhesion strength, S, and the coefficient of thermal expansion, α. These results are summarized in Figure 9-16. Also, it has been shown that polyimide die overcoat, or PIX, can reduce the percent of die or pad delamination by up to 30% on parts subjected to temperature cycling [1,4] as well as mechanically support air bridges during plastic encapsulation, provide a more uniform electrical environment for the die, and provide protection to the surface of the die. Figure 9-17 shows cross sections of three PIX-treated dies. It has been reported that the PIX shown in Figure 9-17(a) yields the best improvement in reliability [1]. The PIXs shown in Figures 9-17(b) and (c) are not as desirable, because, respectively, they cause wire-bond stress and do not protect the die surface.

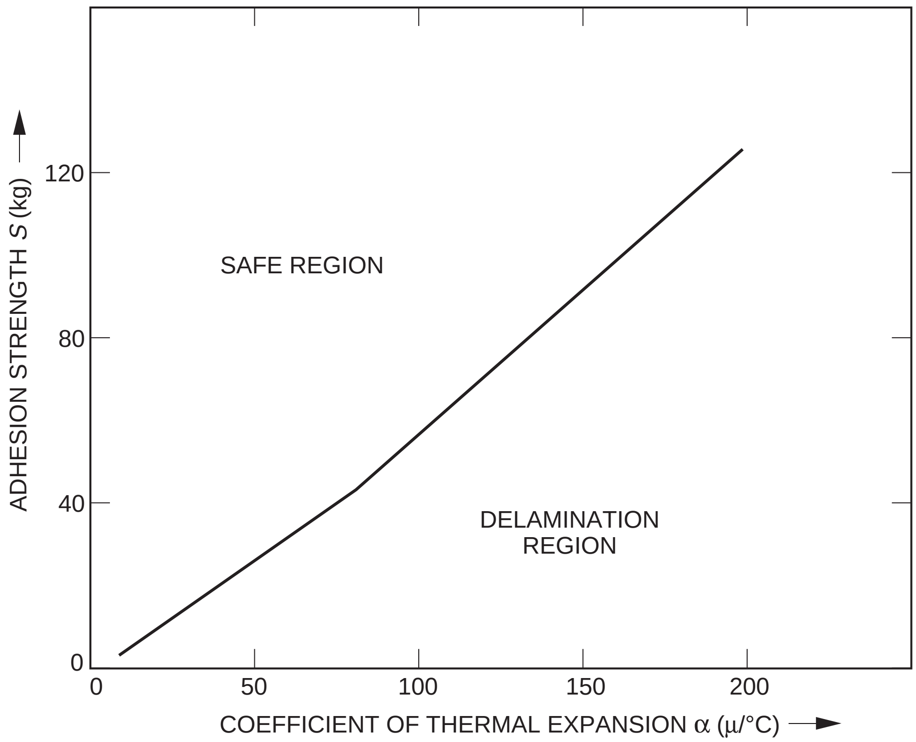

Figure 9-16. Mold compound properties.

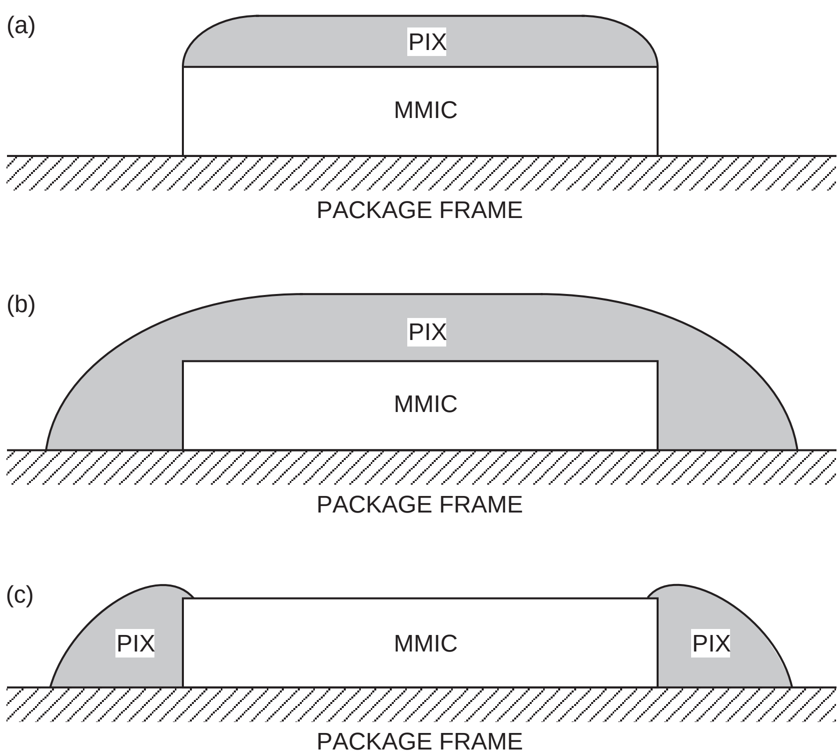

Figure 9-17. Polyimide die overcoat (PIX) on MMIC die: (a) PIX on MMIC top surface only, (b) PIX on MMIC and package frame, and (c) PIX on package frame and sides of MMIC only.

The last mechanisms by which a chip can fail in a plastic package are caused by bond-wire sweep and lift-off, which in turn are caused by the viscous flow of the molten-plastic mold compound. The viscosity of the molten plastic is a function of the filler particle size and concentration. Figure 9-18 shows the typical geometries of wire bonds with different die settings. Studies [5] show that of the three wire bonds, the one with the raised die experiences the largest maximum displacement. Further, the raised die and the downset die experience maximum stress at the ball bonds. In these cases, plastic deformation of the ball bonds is a major cause of failure. In contrast, the wire bond for the double-downset die suffers only elastic deformation. Thus, the double downset is the recommended device layout to minimize bond wire sweep.

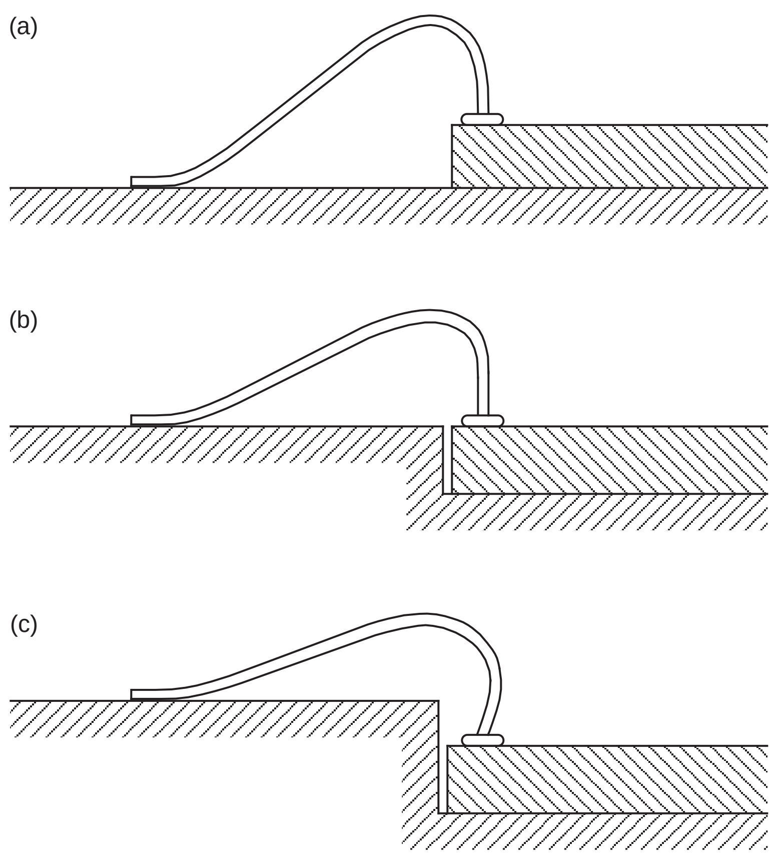

Figure 9-18. Typical geometry of wire bond with different die settings: (a) raised, (b) downset, (c) double downset.

References

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