Surfaces, Interfaces and Microelectronic Packaging

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The broad field of "microelectronic packaging" relates to the assembly and interconnection of semiconductor devices. At the center is the Si die, analogous to the engine of an automobile. However, in order for this "engine" to be able to function in a useful manner in systems such as computers and others reliably over the useful lifetime of the system, it needs to be "packaged" and inter-connected. In general, packaging begins with dicing, i.e., the sawing of the wafer into individual dies or chips, which are then removed and packaged individually. The final step in the process is the completion of a component, such as a Dual Inline Package (DIP) shown in Figure 1, perhaps the simplest packaging that is still very widely used. The assembled components are then mounted onto a printed wiring board (PWB), typically by soldering.

Of the total cost involved in producing a microelectronic component, between 50% to 90% goes towards the packaging, depending on the specific type of die and packaging technology. However, approximately 95% of the reliability issues (failures) are actually related to the packaging rather than the die. This is analogous to modern automobiles in which reliability issues are very seldom related to the failure of the engine itself (as long as reasonable care is taken of the engine, i.e., regular oil changes), but rather the myriad of other "components" that are essential for reliable and safe functioning of the automobile.

As can be seen in Figure 1, there are a variety of surfaces and interfaces, the integrity of which needs to be maintained at all times, in order for the die to be able to function reliably over its service life. Some of these surfaces and interfaces are obvious while others are not. These surfaces and interfaces and the role they could possibly play in the reliability of the component over its service life include the following:

(a) Surface of the passivation layer on top of the die; affects adhesion of the mold compound to the die
(b) Surface of the back side of the die; affects adhesion of die attach adhesive to the die
(c) Upper surface of the die attach pad; affects adhesion between the die attach adhesive and die attach pad
(d) Lower surface of the die attach pad; affects adhesion between the die attach pad and mold compound

(e) Surface of Al bond pad on die; affects bonding between the Au bond wire and Al bond pad which in turn affects the resistivity of the electrical pathway

(f) Surface of the Cu lead frame; affects the wedge bonding of the Au bond wire to the Cu lead frame; affects the bonding between the mold compound and the lead frame which in turn can affect the hermeticity of the package; affects the bonding between the lead frame and the printed circuit board

(g) Interface between the filler in the mold compound and the mold compound itself; lack of complete adhesion can result in the existence of pathways for moisture intrusion into the package.

The integrity of these surfaces can have a major impact on the long term reliability of the component (packaged die). If adhesion between the various components in the package is poor delamination can occur, resulting in intrusion of moisture into the package. It can also affect the mechanical strength of the package.

The detailed composition of the interface can also change over time. This is illustrated in Figures 2 and 3. As can be seen, the composition of this interface between an ENIG (electroless nickel immersion gold) coated Cu lead frame and the SAC 305 Pb-free solder changed significantly when thermally aged at $150^{o}C$ for 30 days.

This presentation will begin with a brief background to microelectronic packaging and the reliability issues, especially those related to surfaces and interfaces. This will be followed by a more in-depth discussion of surfaces involving solders and how these surfaces can change over time and the nature of those changes.

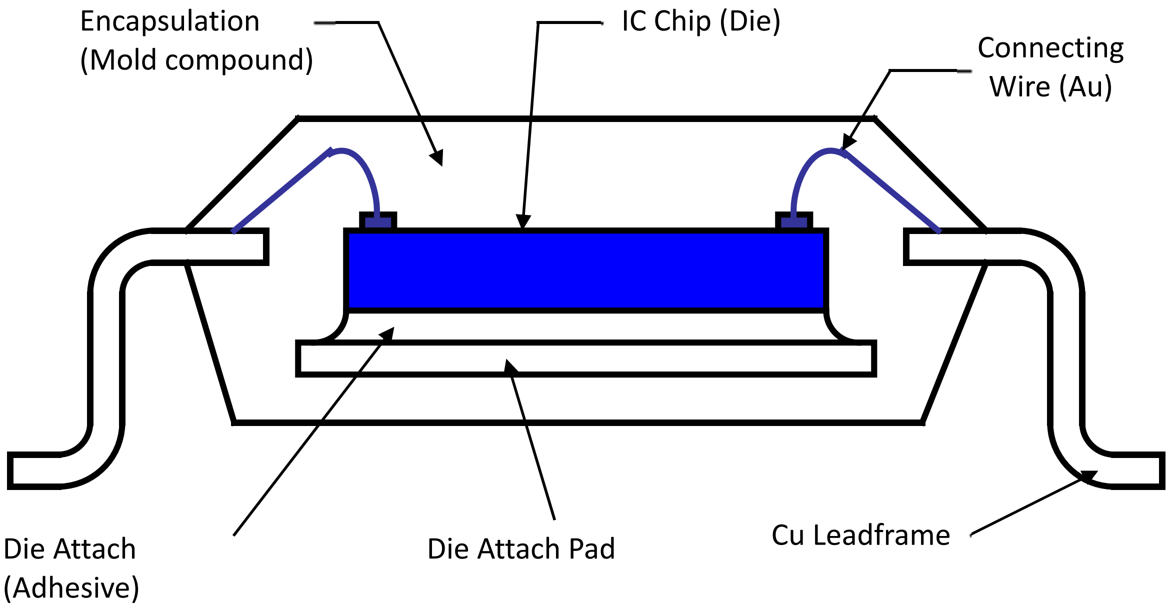

Figure 1: Schematic Cross-Section of Dual-Inline Package

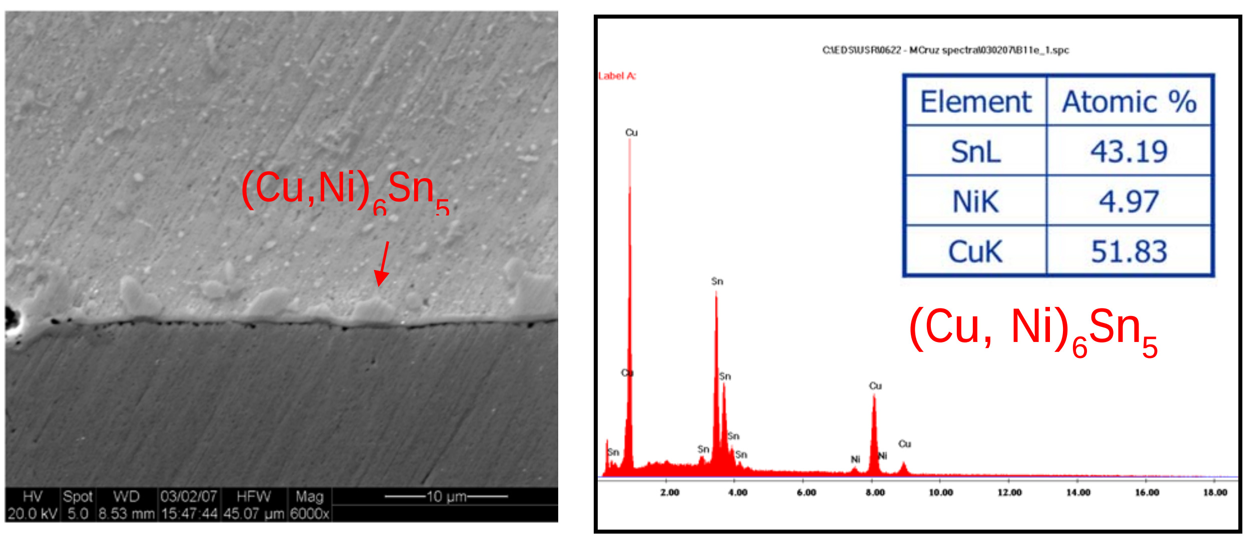

Figure 2: Composition of ENIG-SAC 305 Interface prior to aging

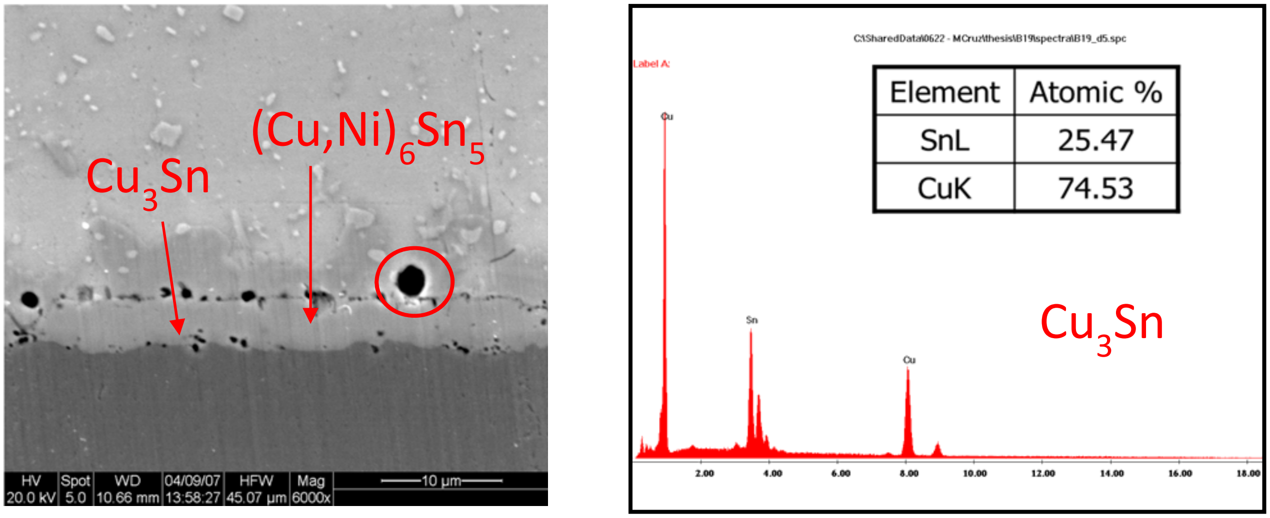

Figure 3: Composition of ENIG-SAC 305 Interface after 30 day aging at 150°C