Studies on Wettability between Solder Bump and Substrate Finishes for Reflowable Underfill Application

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Abstract

- **Background**

Flip chip assembly is gaining importance for IC interconnection due to the package density and speed increase requirement. However, the difference of thermal expansion coefficient between the chip and substrate causes significant reliability problem. Although this can be resolved by dispensing underfill between chip and substrate, this additional process will take longer time and increase the overall cost. In order to overcome this, a new process that is compatible with SMT assembly has come out. The overall process consists of dispensing underfill on substrate/PCB, pick and place die, reflow in which solder reflow and underfill cure occur simultaneously, and off-line post cure. As reflowable underfill is an integration of epoxy and fluxing agent, it possesses self-fluxing capability. On the other hand, the fluxing capability/wettability is affected by affinities between solder bump and substrate finishes. The scope of this study is to understand the wettability of reflowable underfill when being applied to assembly with different substrate finishes. Discussion will also be given on how to resolve these issues.

- **Experimental**

For eutectic solder bump Sn63/Pb37, both Ni/Au, organic solder preservatives (OSP) and eutectic solder clad substrates were evaluated. For high lead solder bump Pb97/Sn3, only eutectic solder clad substrate was studied. X-section was used to characterise the solder joint integrity that was the reflection of affinities between solder bump and substrate finishes.

- **Major Results**

Reflowable underfill shows excellent wettability for eutectic solder bump with both Ni/Au and OSP finishes, as shown in Figure 1. This fact results from the robust anti-oxidation property for both Au and OSP. On the other hand, about 20% dry joints have been found when solder clad substrate is used under 10N bonding force, as illustrated in Figure 2. Subsequently, the bonding force was increased to 20N, and 100% good joint was formed, as shown in Figure 3. This observation suggests that there must be a tight physical contact between bump and solder cap on the substrate before flux took effect and made solder reflow to form interconnection joint. Meanwhile, more dry joints have been found for assemblies with high lead solder bump and eutectic solder clad substrate, most probably because of high lead solder being more prone to oxidation. This explanation has been enhanced via the fact that good joints can be formed after the high lead solder bumps were pre-cleaned to remove the oxide, as show in Figure 4. Moreover, the non-wetting issue becomes aggravated if the bumped chips are not stored under proper conditions before assembly. In summary, substrate finishes and their affinities to different bumps play a crucial role in the formation of interconnection joint for reflowable underfill application. In general, Ni/Au finish is strongly recommended from wettability standpoint, while further studies are needed to assess the reliability for various structures.

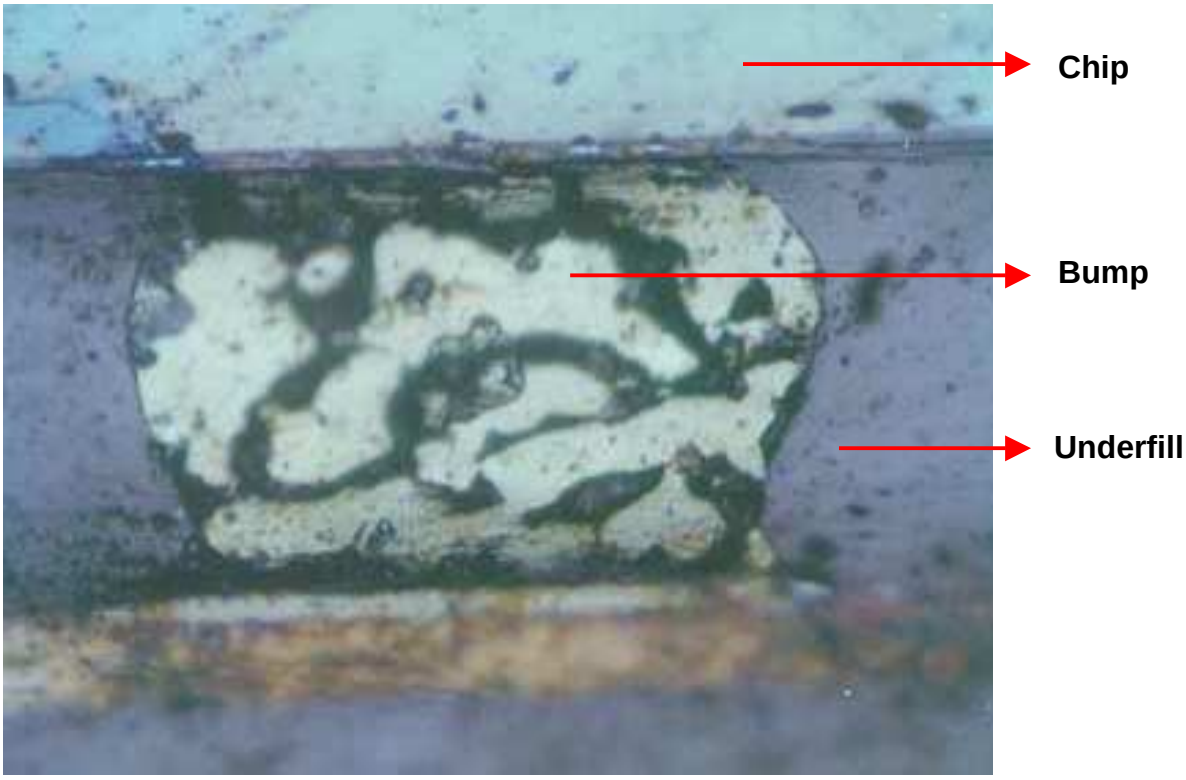

Figure 1. Eutectic solder bump with Ni/Au finish.
Bonding force: 10N

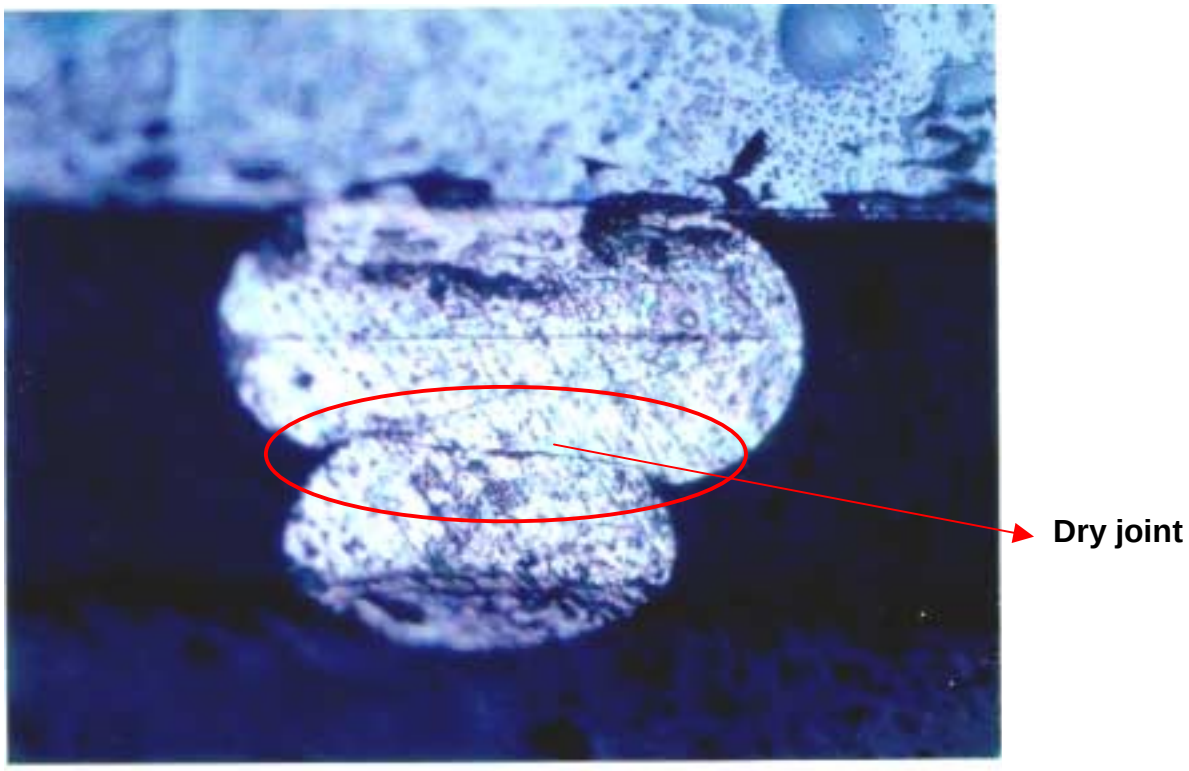

Figure 2. Eutectic solder bump with solder clad finish.
Bonding force: 10N

Figure 3. Eutectic solder bump with solder clad finish. Bonding force: 20N

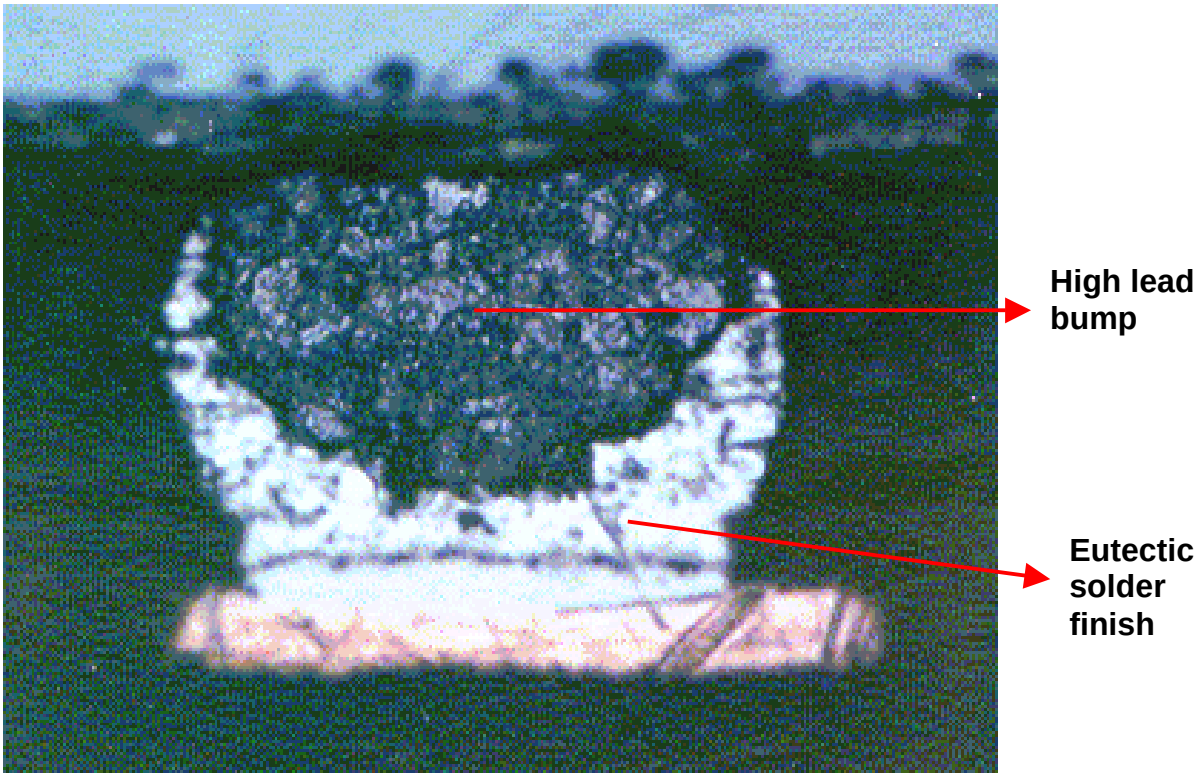

Figure 4. Pre-cleaned high lead solder bump with eutectic solder finish. Bonding force: 10N