Introduction

For many years, flip chip packages have most commonly been inspected in a bare die state. This has allowed for higher frequency transducers (e.g. 200 MHz and higher) to be used to ultrasonically inspect for solder bump defects (such as cracks, voids, or disconnects) and underfill defects (such as voids and filler particle density concentrations). However, the newer, more advanced flip chip packages with their thin die, new dielectric layers, and overmolding offer challenges to the traditional mode of inspection.

Molded Flip Chips

Filler particles added to molding compounds and underfill compounds to improve their thermal properties (conductivity and expansion) deflect ultrasonic signals. As the ultrasonic beam propagates though the mold compound, it scatters off of the filler particles weakening the signal or blocking it altogether (Figure 1). This scattering effect causes shadows of the filler particles to be seen in images from the interfaces of interest (such as the die top, die-to-bump and bump-to-substrate), and prevents accurate inspection. In many cases, the filler particles are larger than the solder bumps / Cu pillars to be inspected limiting the ultrasonic inspection capability. The solder bumps / Cu pillars may be hidden by a filler particle shadow. Using a lower frequency transducer, such as the S1463 75 MHz 12mm, can help with penetrating through the mold compound, but there will still be some shadow effects in the resulting images that limit the inspection.

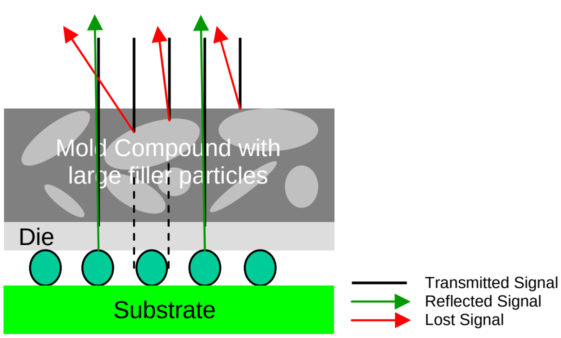

Figure 1: Schematic of the layers in a molded flip chip and the filler particle scattering effect

Polyimide (PI) Layer

The addition of a PI Layer weakens the ultrasonic signal passing through it, reducing image contrast of the interfaces of interest below it. In some cases, shadows of PI layer variations are visible, preventing accurate inspection. As with the filler particle shadow effect, features below PI layer variations may be concealed in typical ultrasonic images. When a PI layer is present in an overmolded flip chip, the effect of both materials can make standard ultrasonic inspection quite challenging. When inspecting a bare die sample with a PI layer, UHF frequencies can usually still be used, but a longer focal length is often necessary to penetrate to the interfaces of interest. However, for more attenuative PI layers or if both the PI layer and mold compound are present, a lower frequency transducer, such as the S1463 75 MHz 12mm, will help with penetration to the interfaces of interest.

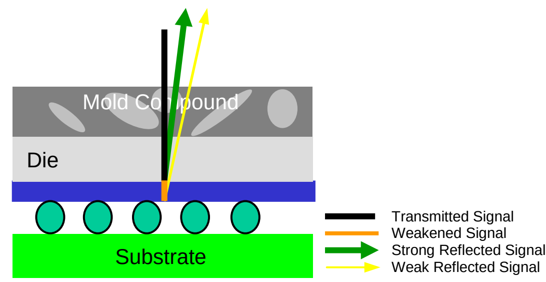

Figure 2: Schematic of a molded flip chip with a PI layer and the PI layer weakening effect

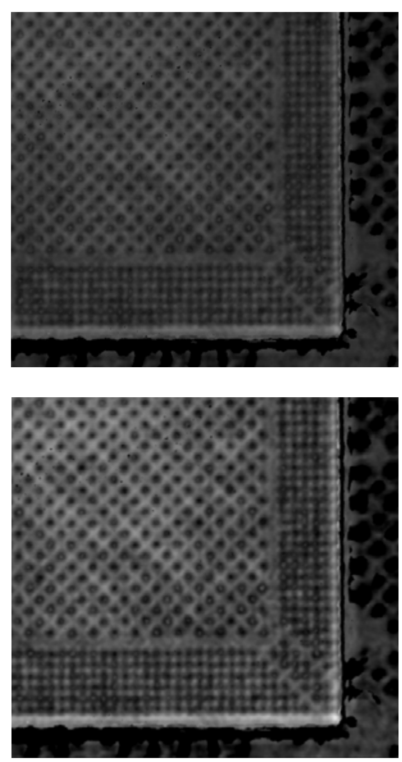

Figure 3: (top) standard ultrasonic image of a molded flip chip, (bottom) MFCI™ image of the molded flip chip showing improved spatial resolution and contrast

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MFCI™ Technique

By examining the physics of the ultrasonic beam interaction with the mold compound and with the PI layer, Sonix™ has been able to develop a molded flip chip imaging (MFCI) technique for reducing the scattering and attenuation effects of the mold compound and PI layer. Images produced using the MFCI™ technique show improved spatial resolution and contrast (Figure 3) as well as better edge resolution (Figure 4).

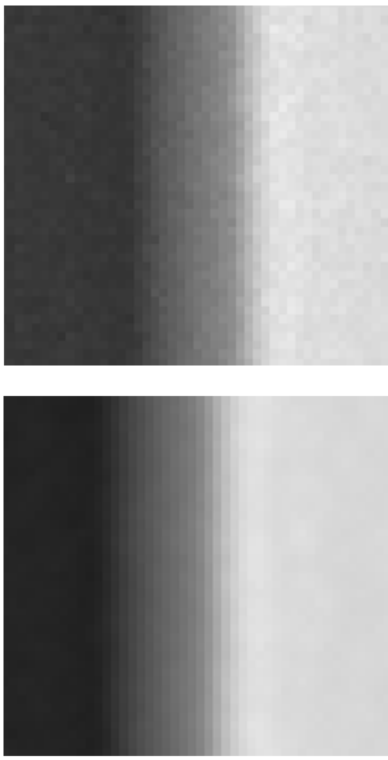

Figure 4: (top) standard ultrasonic image of a vertical line feature in a calibration sample, (bottom) MFCI™ image of the same vertical line feature showing much cleaner edge resolution

Discussion

Although the MFCI™ technique was developed to address molded flip chip imaging issues, it has been found to improve spatial resolution, contrast, and edge resolution in any images that require going through a layer with particles or other scattering effects. An example of such a material is flip chip underfill, which also contains filler particles. Images of the solder bumps / Cu pillars within the underfill layer or at the substrate interface are improved when using MFCI™.

Note

The MFCI™ technique, when present on a Sonix™ SAM system is activated under the Advanced menu item.

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