## Introduction

For many years, microelectronic packages consisted of only a few layers. However, with the advent of 3D packaging, the number of layers in a sample has increased significantly. The increased layers could be the addition of overmold, metallization / dielectric layers below a die, multiple stacked silicon die, or all of the above. These additional layers offer a challenge to SAM inspection in that the reflections from deeper layers are weaker than the reflections from shallower layers. Because the layer thickness has also decreased, this is not typically due to the deeper layers being out of the focal zone of the transducer. Instead, it is the cumulative effect of the reflections from each of the shallower layers reducing the amount of ultrasonic signal transmitted to the deeper layers (Figure 1).
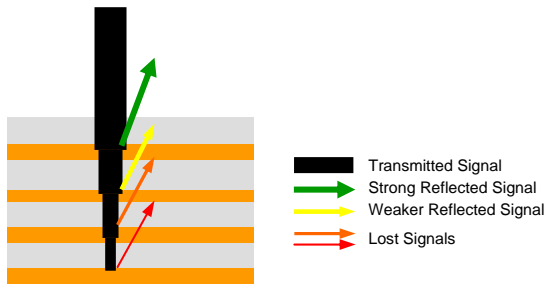

Figure 1: Schematic of a multilayer sample showing how the transmitted ultrasound gets weaker with each layer also weakening the reflected signals from deeper layers.

With current technology, there are two options to try and overcome this limitation of physics. First, the gain can be increased so that there is some imageable data from the deeper interfaces. However, this often results in the images from the shallower interfaces being saturated, which hides any potential defects in those layers. Second, multiple scans at different gain settings may be done so that imageable data is obtained from all interfaces in the sample. However, this approach significantly adds to the inspection time.

Sonix™'s patent pending Stacked Die Imaging (SDI™) technique allows the user to equalize the amplitude of deeper reflections without affecting shallower reflections, and allows for all interfaces of a 3D sample to be inspected in a single scan. SDI™ provides more meaningful inspection data in a shorter inspection time. It can also allow for higher frequencies, which are too weak to penetrate with standard technology, to be used for higher resolution inspection.

Lidded Flip Chip Example

Although a lidded flip chip is not a newer 3D package, it does provide a simple example of a situation where a deeper interface reflection is much weaker than a shallower one. Depending on the lid attach material used, it can be quite difficult to penetrate to the die top. As a result, the die top reflection is much weaker than the lid-to-attach reflection (Figure 2). However, using the SDI™ technology, a gain profile can be created that applies more gain to the die top reflection without impacting the lid-to-attach reflection (Figure 3). In both cases, a S1463 75 MHz 12mm transducer has been used.
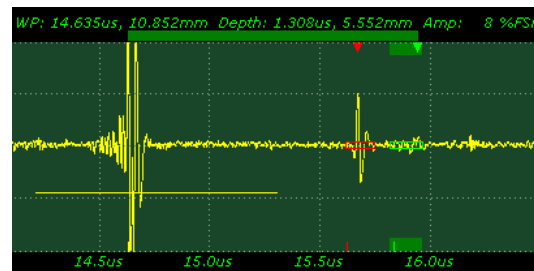
Figure 2: A-scan from the lidded flip chip sample, showing the die top reflection (green gate) much weaker than the lid-to-attach reflection (red gate)
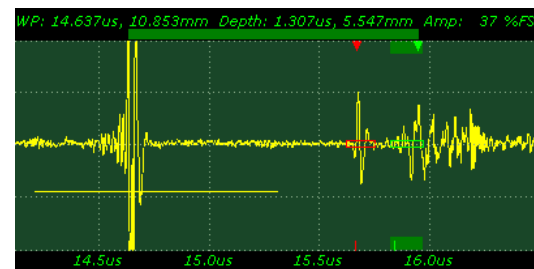

Figure 3: SDI™ A-scan from the lidded flip chip sample, showing the die top reflection (green gate) equalized to the lid-to-attach reflection (red gate)

Comparing the resulting images from the standard and SDI™ setups, it is seen that the lid-to-attach images are basically identical (Figure 4), while the SDI™ image of the die top is greatly improved over the standard setup image (Figure 5). The die is now clearly visible in the SDI™ image. Shadows of the lid-to-attach and attach layer defects are also clearly visible.

SDI™ Setup

When the SDI™ technology is present on a system, the setup window (Figure 6) is accessed by clicking on the SDI button at the top of the main WinIC™ screen above the A-scan scope. In order to set values
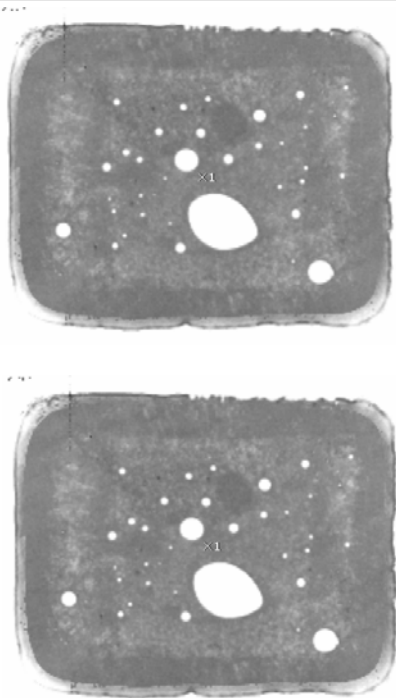
Figure 4: Lid-to-attach image obtained using the standard setup (top) and SDI™ setup (bottom). The images are basically identical.
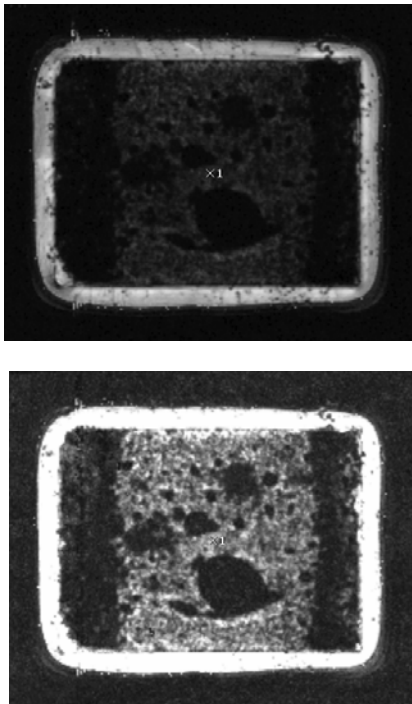
Figure 5: Die top image obtained using the standard setup (top) and SDI™ setup (bottom). The die is clearly visible in the SDI™ image.

for the gain curve, the user first clicks on the Add Point button. Next, the user places a gate over a reflection of interest (e.g. Data Gate 1 on the lid-to-attach reflection) and clicks on the Collect button. This will then fill in the Peak and TOF values for the selected gate in the selected Gain Point Row. To add a second point, the user simply repeats this process and chooses the appropriate gate (e.g. Data Gate 2 for the die top reflection). Any C-scan gate type may be used for the Collect process as long as it is present on the A-scan. Please note that for TAMI™ gates, the user must select the TAMI™ gate of interest using either the mouse or the gate select arrows on the Gate Tab.
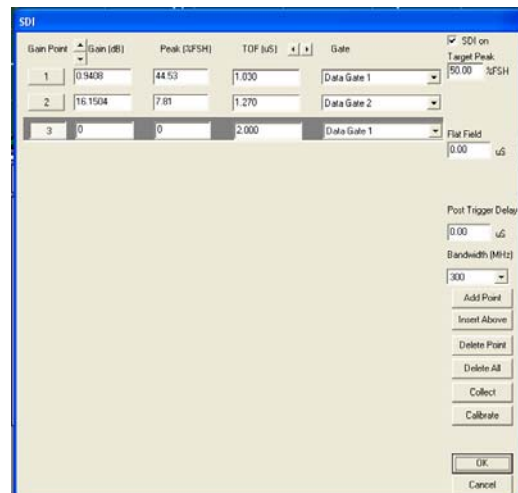
Figure 6: SDI™ setup window

Once all of the gain points of interest have been added, the user can set the Target Peak value (e.g. 50%FSH). This will typically be close to the %FSH of the shallowest reflection of interest. Next, click on the Calibrate button to automatically determine the gain required for each point to reach the Target Peak level. Once the gain profile is entered, the user checks the "SDI on" checkbox, and the gain profile is applied and will immediately be seen on the A-scan. Any slight adjustments required can be made using the up/down arrows or by manually typing in the appropriate text boxes.

The SDI™ parameters are saved with the parameter file, so an operator using a pre-saved parameter file can just load it and say Scan.

Note
The SDI™ option is available on Echo™ and Echo VS™ systems or as an upgrade on Fusion™ and Vision™ systems. WinIC™ 4.6.x or later is required.