



Perfecting the Package – Molded Underfill (MUF)

Understanding Ultrasonic Technology for Advanced Package Inspection



Perfecting the Package – Molded Underfill (MUF)

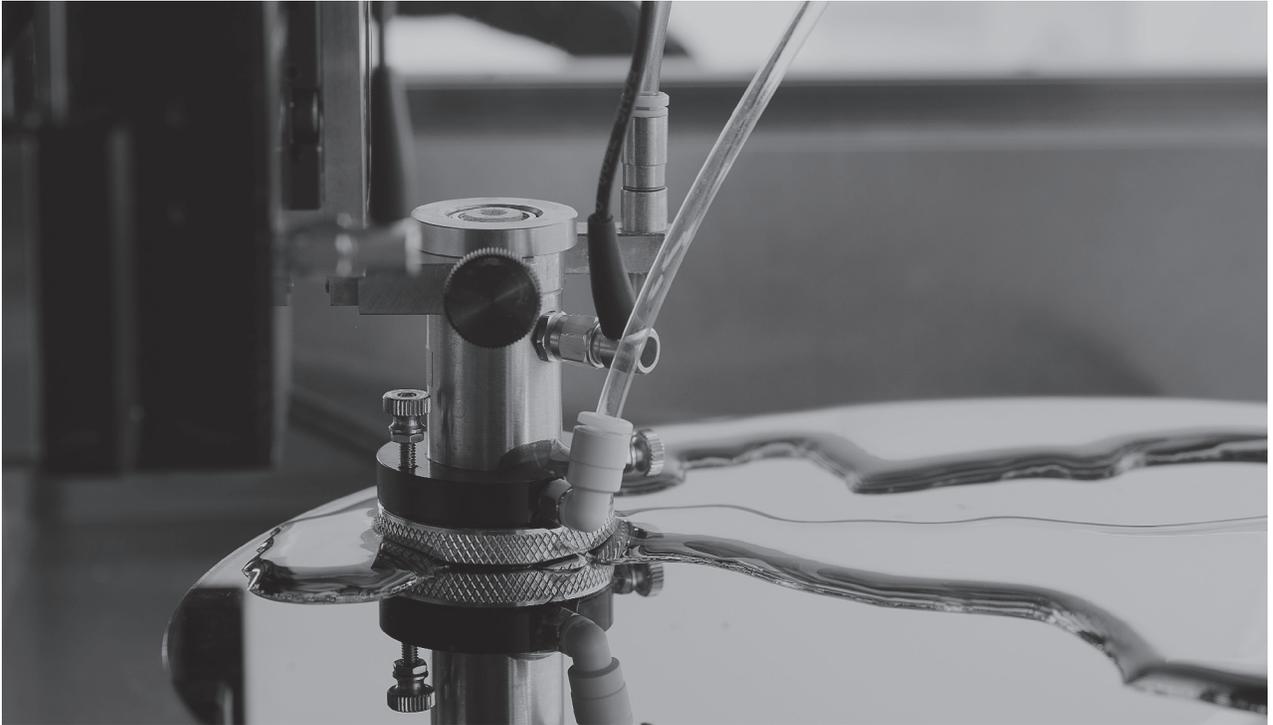
Understanding Ultrasonic Technology for Advanced Package Inspection

Advanced silicon package manufacturers are literally changing the world – enabling devices that are smaller, more powerful, more robust, more affordable. But all these advancements depend on techniques – such as molded underfill, Cu pillars and stacked dies – that make package inspection much more challenging than in the past.

Production yield and quality assurance will always be crucial to success, and the limitations of the inspection system should never stand in the way. To the contrary – no matter how difficult the challenges, package inspection should play an integral role in helping identify and correct production problems, and validating the quality of every package that comes off the production line.

Sonix stays current with the latest in advanced package technology, including how packages are fabricated, where problems may occur, and how to penetrate the most difficult molded layers and stacked dies to clearly reveal any defects. This white paper provides an overview of the most common challenges we see today for inspecting packages that incorporate molded underfill (MUF).

We also offer white papers for advanced Cu pillar inspection and bare or overmolded stacked die inspection. All papers in our advanced package inspection series provide recommendations for overcoming the specific challenges of each package type to get the clearest inspection images possible while maintaining production-line speeds.



MUF Inspection

Molded underfill (MUF) is increasingly being used to lower costs and increase throughput in flip chip assembly, while enabling thinner packaging and improving thermal performance. Although MUF provides a major advancement over the older capillary underfill (CUF) process by combining underfill and overmold processes into a single step, the use of a single material for both brings new inspection challenges.

An effective inspection system for MUF packages must be able to clearly image defects that may include:

- Incomplete wetting of bumps to the die and substrate sides
- Cracking of bumps
- Absence of bumps
- Voids or delamination in the underfill
- Mold defects
- Defects of the polyimide layer, if present

Inspection Challenges

Scattering of the signal from filler particles

The overmold layer is not as transparent to ultrasound as bare silicon. In addition, the filler particles added to the epoxy base to improve thermal properties tend to scatter the ultrasonic signal. Particles that may typically be in the range of 200µm can make it difficult to clearly image defects that may be 20µm or smaller. Higher-frequency signals are more prone to scattering effects that can obscure the interfaces beneath.

Edge resolution

Solder bump or Cu pillar defects at the edge of the die can be difficult to image clearly when the ultrasonic beam straddles the edge. Attenuation and scattering of the ultrasonic signal due to a particle-filled overmold layer can make edge resolution even more challenging.

Distinguishing defective bumps or pillars

The signal “scatter” caused by filler particles can also create shadows and artifacts in the image that make it difficult to reliably see the difference between normal and defective interconnects. In extreme cases, shadowing may cause bumps or pillars to be completely obscured.

Presence of polyimide (PI) layer

The addition of a polyimide (PI) layer weakens the ultrasonic signal passing through it, reducing image contrast and exacerbating the challenges we’ve already discussed. At higher ultrasonic frequencies, it can be difficult to achieve the penetration required to clearly resolve the interfaces of interest.

Warping of thin dies

As manufacturers use thinner dies to build smaller, more complex chips, warping of dies has become a more common problem. Although minor warpage may not affect the function of the die, it can make ultrasonic inspection more difficult as the optimum focal length varies across different areas of the die.

Although minor warpage may not affect the function of the die, it can make ultrasonic inspection more difficult as the optimum focal length varies across different areas of the die.



Inspection Recommendations for MUF Packages

The challenges posed by advanced semiconductor packages call for advanced inspection technologies. Sonix offers several solutions that can be used in combination to achieve the best possible inspection results for any package type and production goal.

S-series Transducers

Choosing the optimum transducer frequency is crucial for achieving the sample penetration and image resolution required for a particular inspection application. For MUF inspection, we typically recommend transducer frequencies from 75 MHz to 150 MHz or higher, depending on filler particle size.

Our proprietary transducers are designed in-house to provide the clearest possible imaging specifically for the packaged semiconductor industry. In selecting the right frequency for MUF inspection, the goal is to achieve optimum sample penetration and rejection of shadows/artifacts. Precise selection and control of signal gain ensures effective signal penetration and brings regions of interest into the best possible focus, without unwanted image artifacts.

MFCI™ Technique

Sonix has developed an exclusive Molded Flip Chip Imaging technique for improving spatial resolution, contrast and edge resolution when imaging complex packages.

Although our MFCI™ technique was originally developed to improve molded flip chip imaging, it can improve defect detection in any package application where ultrasonic signals may be scattered by particles in mold compounds or filler layers.

pulse2 Pulser/Receiver

A general-purpose pulser/receiver may not deliver the signal quality and image resolution required for extremely dense advanced packages. Our next-generation pulse2 pulser/receiver provides 12 dB of extra gain and a 4x improvement in signal-to-noise ratio to remove low-level background noise and generate clear images – even when using UHF transducers with their inherently weaker signal. pulse2 also supports higher-frequency pulse echo and through-transmission (TT) images for improved resolution of features and defects throughout the package, including:

- Flip chip/molded underfill (MUF) packages
- Multiple stacked die layers
- Substrate layers
- Metal/dielectric layers



Inspection Recommendations for MUF Packages

Heated Water

Water is used as a coupling medium to transmit ultrasonic frequencies between the transducer and the sample under inspection. Heated water provides much more efficient acoustic coupling than cold or room-temperature water. We offer a patented 40°C heated water system as part of our Image Enhancement Suite, which we recommend for all advanced package designs including MUF inspection.

Flexible TAMI™

Our innovative Flexible TAMI™ (Tomographic Acoustic Micro Imaging) feature allows you to specify multiple “slices” of a sample to be imaged in a single scan. This allows for quick, efficient investigation of multiple interfaces in 3D packages.

Our most advanced TAMI technology is called “Flexible” because you can set the spacing and length for each gate in the TAMI region independently, ensuring that each gate contains meaningful data and that fewer gates are required, minimizing setup time and file size.

Subsurface Follower (SSF)

For in-focus imaging across a warped die, without requiring multiple scans, our subsurface follower (SSF) tracks the internal warped surface and triggers the appropriate gating for the interface scan. SSF compensates for height variations to give a clear, complete view of the interface being analyzed.

We offer a patented 40°C heated water system as part of our Image Enhancement Suite, which we recommend for all advanced package designs, including MUF inspection.



The Sonix Advantage

Sonix has been the innovation leader since 1986.

Today, the ECHO line of scanning acoustic microscopes sets the standard for package inspection speed and image quality to help you keep pace with new packaging materials and difficult form factors. The ECHO platform will remain at the forefront as we continue to add features and enhance performance for years to come.

Choose our ECHO scanning acoustic microscope for package inspection of stacked dies, complex flip chips and more traditional plastic packages. ECHO VS adds industry-leading features for the clearest imaging of molded flip chip (MUF), CSP, MCM, stacked die, hybrids, and other advanced package inspection applications.

Sonix is ISO 9001/2008 Certified. All of our tools are Semi S2/S8 certified.

For more information, visit our website at www.sonix.com.
We look forward to helping you solve your most difficult package inspection challenges.





About Sonix

Established in 1986, Sonix is solely focused on leading the industry in the development of non-destructive ultrasonic testing solutions for microelectronics. We are the world's largest supplier of automated ultrasonic solutions for nondestructive wafer inspection, with over 70 percent market share.

Sonix is solely owned by Danaher (\$18B, NYSE: DHR), providing financial stability with access to resources for investment and information sharing across sister company platforms and technologies.

8700 Morrissette Drive
Springfield, VA 22152
T. 703.440.0222
F. 703.440.9512
www.sonix.com