REAL-TIME FREQUENCY IMAGING TECHNIQUES AND ULTRASONIC SCANNING ACOUSTIC MICROSCOPY (SAM)

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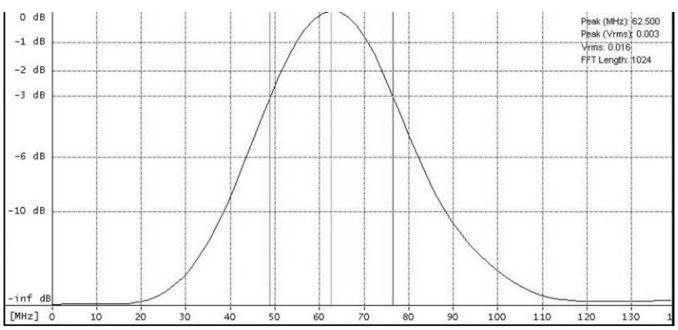
Summary

Frequency imaging use in Scanning Acoustic Microscopy (SAM) applications has been limited due to its computationally expensive nature. While offline frequency analysis has been available for a while, its practical applications are limited. The value of real-time frequency imaging in SAM cannot be overstated. SAM is both a failure analysis and production monitoring tool, requiring real-time imaging capability and verification, making any offline analysis ineffective.

Technology

In SAM, reflected ultrasonic signal contains many frequencies, representing the impact of different materials and their interfaces on the source signal. The ability to parse the reflected signal for frequency domain analysis, in real-time, yields additional SAM information of significant value.



Frequency distribution of reflected signal from a 120 MHz transducer at 8 mm focal length, with center frequency of 60 MHz

Whereas a peak amplitude signal collapses a lot of information into a single data-point, frequency imaging computes the energy within different frequency bands. For example, in the plot above, energy within different 10 MHz bands can be computed and plotted for each data point. This can be computed for any 10 MHz range; 10-20, 20-30… 150-160, or 15-25, 25-35, etc. Any frequency width bin can be created for such computational purposes.

A high performance ultrasonic digitizer is capable of such computations in real-time, along with time domain peak amplitude calculations. By taking advantage of the latest generation multi-stream high end graphics processors, frequency domain calculations are executed in hardware. This technique is borrowed from the gaming industry that has driven rapid development of multi-stream, multi-core graphics processors.

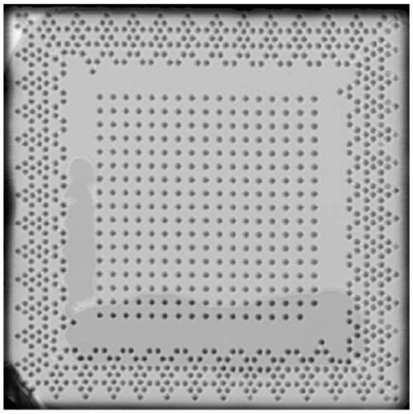
Frequency Energy Images

In some specific cases, frequency images have shown patterns not visible in time domain images. In addition to this clear advantage, frequency images also show extreme noise immunity, as noise is often at the very low end and very high end of the spectrum. It also bypasses the limitations of dynamic range in current generation digitizers by normalizing the energy levels in frequency domain.

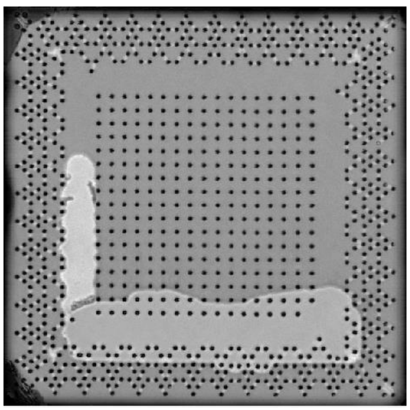
Using energy computed from frequency domain calculations generates higher contrast images, and the energy distribution on interface and feature boundaries is significantly higher than a peak amplitude data point due to its aggregate value. Feature boundaries are captured at a higher contrast.

For use in Failure Analysis and Research & Development, B-Scans of an entire package can be collected and subsequently post-processed to generate a multitude of images for a comprehensive study.

This technique is equivalent to generating multiple images at various transducer frequencies of a common focal length.

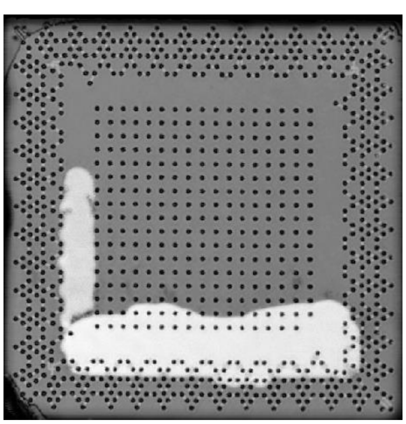


Peak Amplitude C-Scan Image

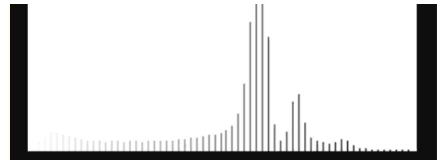


Frequency Energy-1 Image

Histogram of Freq. Energy-1 Image



Frequency Energy-2 Image



Histogram of Freq. Energy-2 Image

Conclusion

Real-time frequency domain images provide valuable information in SAM. Frequency response is an early indicator of material behavior change. Whether this change eventually leads to a defect has yet to be proven. However, packaging engineers and material scientists find great value in studying long term stability and strength of material bonds and changes in physical behavior. Tracking and trending this information could eventually lead to bettering the manufacturing processes by identifying material issues.

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