Acoustic Micro-Imaging of Metal Foam Bonds

Tom Adams, Consultant
Sonoscan Inc.
Elk Grove Village, Illinois

Acoustic micro-imaging reveals the extent of metal foam bonds with solid substrates.

Acoustic microscopes such as C-SAM systems pulse VHF or UHF ultrasound from a scanning transducer into a surface, and receive the return echoes from interfaces between different materials. To image the bond of (for example) an aluminum foam to an aluminum substrate, ultrasound is pulsed into the flat substrate. At each of the thousands or millions of x-y coordinates covered by the scanning transducer, only two results are possible:

- If the ultrasound encounters a uniformly good aluminum-aluminum bond at the substrate-to-foam interface, no echo signal will be returned to the transducer. The *lack* of signal from the aluminum-to-aluminum interface will become a black pixel.
- If the ultrasound encounters an interface between the aluminum of the plate and a pore, the reflection of ultrasound will be >99.99%. The very high amplitude of this echo signal will be converted into a white pixel in the acoustic image, **Fig. 1.**

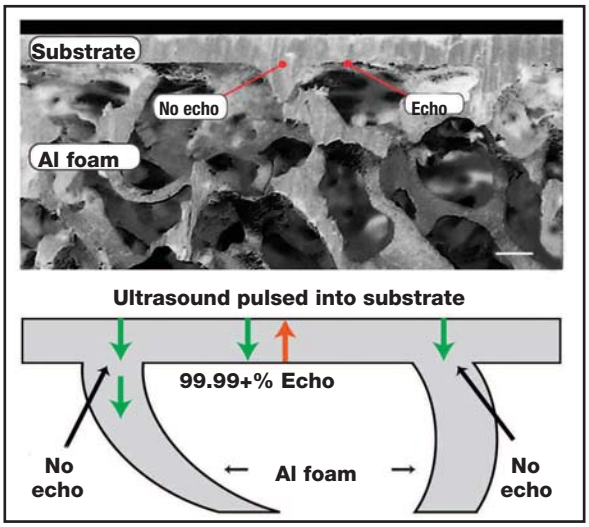

Fig. 1 — *Optical cross section of substrate and foam is at top. Ultrasound pulsed by transducer is not reflected by Al-Al interface where the substrate is bonded to the foam, but is very strongly reflected where the substrate overlies a space.*

Only return echo signals from the depth of interest — in this case, the interface between the plate and the foam — make the acoustic image. Echo signals from below this interface may be received, but they are not used because they are outside of the time window for the critical interface.

These two alternatives created the acoustic image of the sample shown in **Fig. 2**. Ultrasound having a frequency of 230 MHz was pulsed into the aluminum substrate, which was <1 mm thick. Black areas indicate bonds between the various sized elements of the foam and the plate. White areas indicate open spaces. A requirement for this substrate was that bonding between the foam and the plate should cover about 40% of the area. In this small sample, the amount of bonded area measured in the acoustic image was 39.02%.

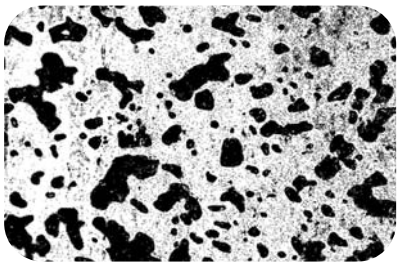

Fig. 2— *Acoustic image of substrate-to-foam bond shows black bond areas and white non-bond areas.*

Additional information is seen in the acoustic image. The numerous tiny black features could be aluminum particles that were deposited onto the plate during fabrication. The many tiny white areas within the black bonded regions could be tiny gaps within the larger bonds, and may weaken the bond.

Metal Foams

Metal foams are typically used in heat exchangers and structural applications where their high surface area, high impact resistance, light weight, and —depending on the material —resistance to high temperatures, humidity, and corrosion are important. Aluminum and copper are the most common foams, but steel, brass, nickel, and zinc are also made into foams.

The two types of metal foam are closed-cell, in which each cell's surface is complete; and open-cell, in which each cell is open to adjacent cells. Open-cell foam forms a complex open network throughout the cells.

In many applications, the foam is bonded to a flat substrate, generally of the same material. Several bonding methods are available, but quality and reliability considerations often require some method of measuring the extent of the bond between the foam and the substrate. Various destructive test methods would be suitable, but acoustic micro imaging makes the whole bond area visible rather than just a single slice, and it is nondestructive. If, for example, physical sectioning of the sample is needed, acoustic imaging beforehand would show engineers where to section.

Whatever the material or the application, success depends largely on the integrity of the bond between the foam and the substrate. Acoustic micro imaging images and characterizes the bond without the need to destroy the sample.

For more information: Sonoscan, Inc., 2149 E. Pratt Blvd., Elk Grove Village IL 60007; tel: 847 437-6400; fax: 847 437-1550; info@sonoscan.com; www.sonoscan.com