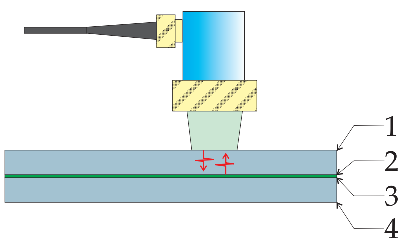
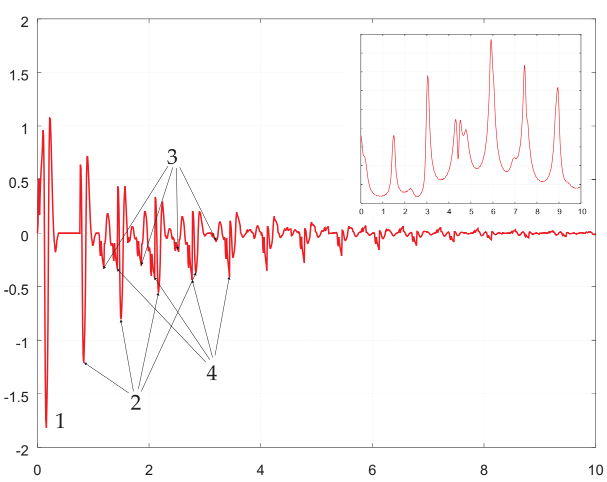
Centre for Imaging Research and Advanced Materials Characterization

Adhesive Bond Characterization
Feasibility Study: Pulse-Echo Imaging



Pulse-echo imaging is well suited to the adhesive bond geometry. The strength of acoustic pulses reflected from each interface is very sensitive to the physical properties of the media on either side as well as elastic conditions at the boundary itself. The images, obtained using a commercial SAM, demonstrate the possibilities of the technique for detecting various types of defects; also the difficulties in dealing with the metal-polymer acoustic mismatch.

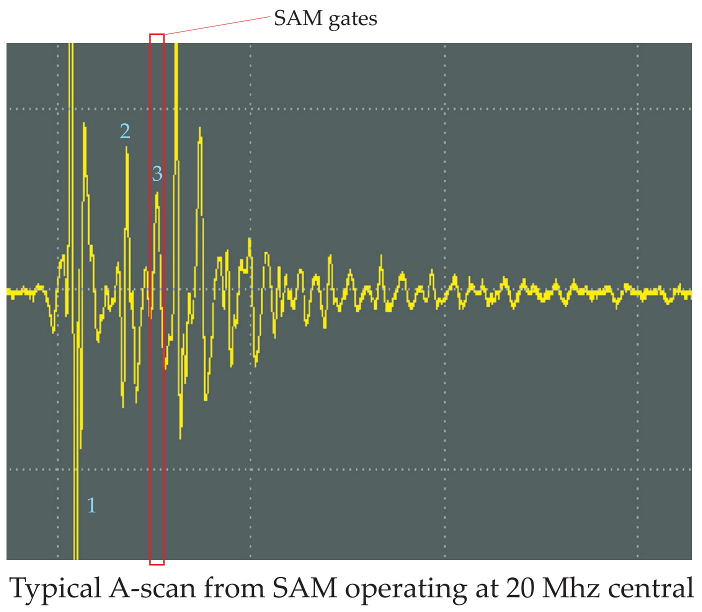


(Left) Simulated pulse-echo signal for 2 mm substrate thickness and 7.5 MHz central frequency. Reflections from the various interfaces are reasonably distinct (1-4). Inset shows resonance spectrum below 10 Mhz.

Physical Principles

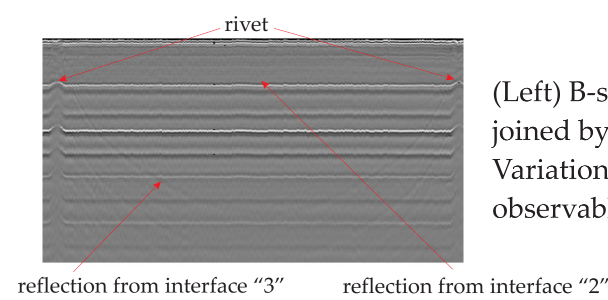
A broadband transducer is used to generate a sharp acoustic pulse, which propagates through the structure (above), and collecting the train of pulses (A-scan) reflecting from each interface (1-4). The data available from the A-scan includes the times of flight and amplitudes of various reflections, which may be individually gated and analyzed (below). Scanning, whether mechanically or electronically, yields a two dimensional depth (B-scan) or plane (C-scan) data set, comparing the features at different physical locations.

Spatial resolution depends on the scanning system and the beam width, which is limited by the transducer (or array element) size and curvature, and wavelength. Temporal (depth) resolution depends on pulse width. Generally higher frequencies increase resolution at the expense of a weaker signal.



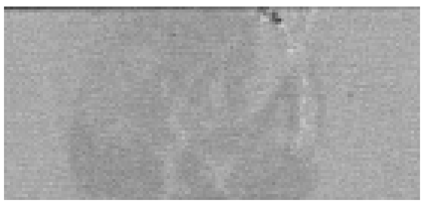
(Above) Typical A-scan from SAM operating at 20 Mhz central frequency. Gates are shown for C-scan imaging of the signal reflected from a defect within the adhesive.

Results

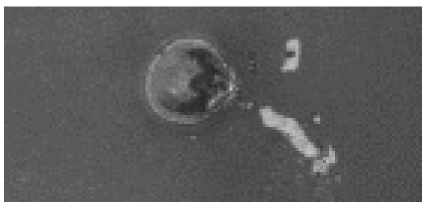


(Left) B-scan of pair of sheets joined by rivets and adhesive. Variation in adhesive thickness is observable.

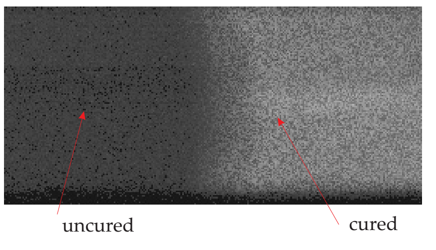
(Right) SAM image of a contact disbond (adhesion failure) simulated by Teflon contamination of one surface.



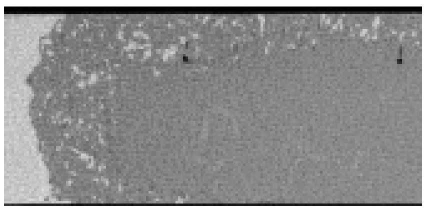
(Right) Burned adhesion zone around resistance weld. Exhaust vapor channel is clearly visible.

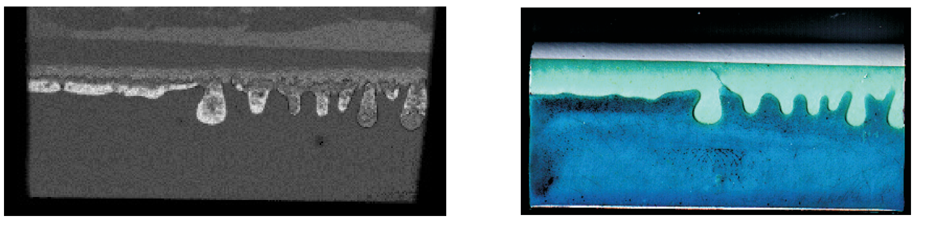


(Right) Image of a sample comparing cured and uncured regions (in transmission mode).



(Right) Regionof adhesive exposed to water contamination prior to curing. Porous region at edge of adhesive is the effect of humidity.





(Above) Direct comparison of acoustic (left, before pealing) and optical (right, after pealing) images of adhesive inside a bonded structure.

Future Development

- Move to fully portable, handheld system, based on existing array technology.
- Optimize transducer design for various substrate and adhesive thicknesses and materials.
- Integration with resonance spectroscopy technique

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