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Abstract

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Keywords

Nondestructive Evaluation

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ACOUSTIC MICROSCOPY VIA SCANNING

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ABSTRACT

We offer via posters some of the latest images recorded with the scanning acoustic microscope operating near 2.5 GHz.

Our report at the 1978 Review included a description of the scanning instrument which had been scaled up in frequency to 3 GHz. This was accomplished in large part by fabricating acoustic lens with smaller radii and by heating the liquid to reduce the absorption. In our report for this year, we will present the results of our material studies as carried out with the new instruments operating near 2.5 GHz. We will include results on four different materials - steel, Cobalt-Titanium, brass and alumina ceramic. Each of these have distinctive characteristics in the acoustic micrographs and each of these have information which is distinct from their optical counterparts.

The sketch of Fig. 1 outlines the essential features of the instrument. The lens itself is a spherical cavity in a sapphire block. When this cavity is filled with water it serves as an ideal lens which will converge the acoustic energy to a narrow waist at the focal point. The waist diameter is less than the acoustic wavelength and it is this feature that determines the resolving power of the instrument. The overall view of the sapphire crystal with the acoustic film transducer is shown in the upper right. The sample surface is scanned across the focused beam and it is the reflected signal from this surface that we monitor and display. The mechanical set-up for implementing the mechanical scanning is shown in Fig. 2.

The first illustration of this type of reflection microscopy is shown in Fig. 3. There we see the optical and acoustic comparisons of the steel surface before and after the preferential etching. It is a low-alloy steel used for auto bodies. One has to use chemical etching in order to bring out the grain boundaries in the optical images. On the other hand, the acoustic image shows these boundaries before the etching process. Also the different grains appear here with different contrast. It is this texture that we find in the acoustic micrograph that is important. We attribute this to different orientation of the grains. We have determined from previous studies that the reflected signal is sensitive to the elastic properties of the surface under examination. In turn, the various orientations show up since the individual grains are anisotropic and they present different elastic properties as their orientation is altered.

In Fig. 4 we present the optical and acoustic comparison of a surface of the alloy Cobalt-Titanium. This material has condensed in different phases - each with a different ratio of cobalt to titanium and each with different elastic constants.

The central points of interest in this material are the various regions of high reflectivity (bright regions) in the acoustic images. The corresponding points in the optical images reveal nothing. But as the sample is etched the bright points in the acoustic field turn out to have a much higher etch rate and they form small surface cavities in these regions. We are unclear about the origins of these pits. They might be attributable to different material compositions or perhaps subsurface cavities. It is a clear demonstration of the power of acoustic microscopy to delineate various inhomogeneities in material surfaces.

In Fig. 5 we show the polished surface of a brass sample. Again, the boundaries between grains and the twin boundaries stand out with high contrast. The contrast in the optical image is much less.

In the final images of Fig. 6 we present the comparative images of the surface of alumina ceramic which is partially coated with gold. The SEM images and the optical images exhibit much less contrast than does the acoustic images. Also, we see imperfections in the gold film that are uninteresting in the image taken with the SEM.

The acoustic microscope can now be used to record image surface and subsurface detail of various materials with a resolution similar to the optical microscope. The content of the acoustic image is often greater than the optical images. The two forms of microscopy taken together reveal much more information on material structures and formations.

ACKNOWLEDGEMENT

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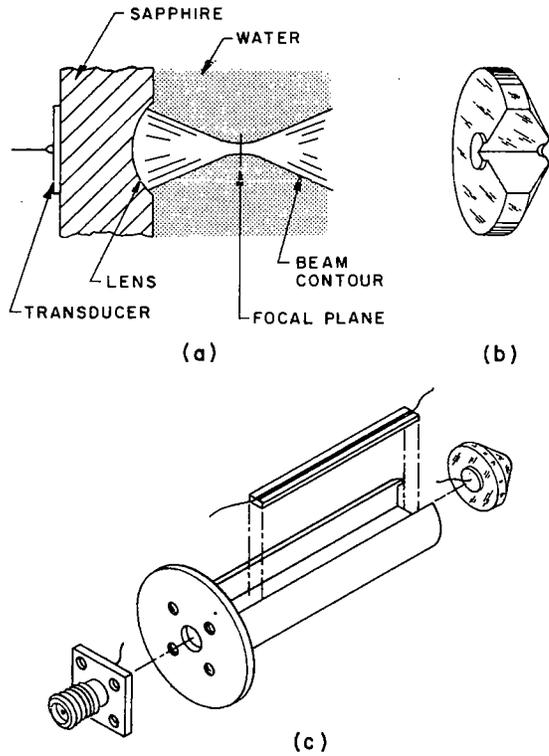


Fig. 1 (a) Piezoelectric transducer and acoustic lens as used in the acoustic microscope.
 (b) Sapphire rod which carries the transducer and the lens.
 (c) Lens holder with a matching network for the transducer.

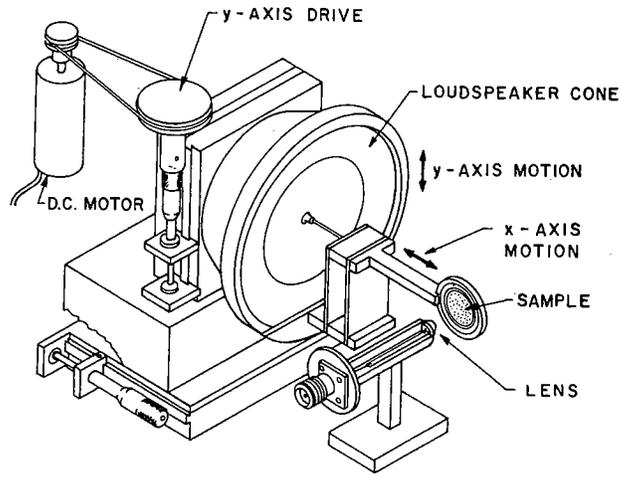
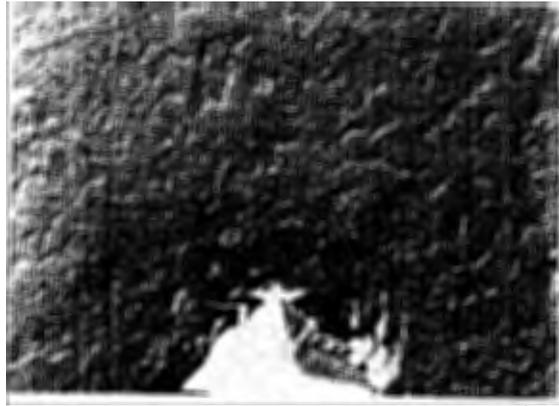
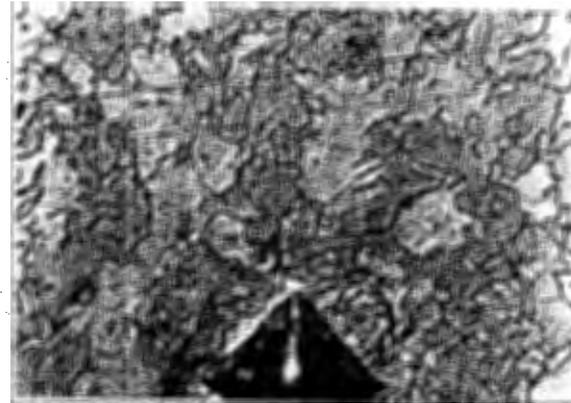


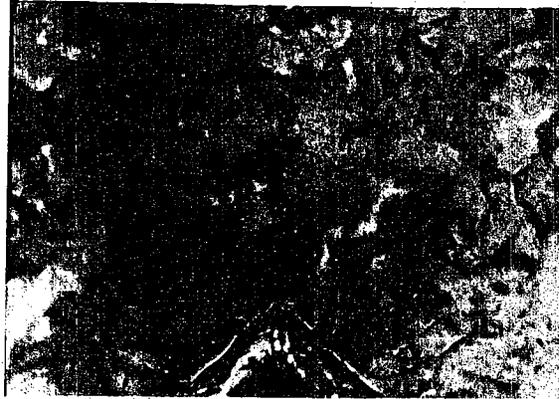
Fig. 2 The components used for the mechanical scanning.



A



B



C



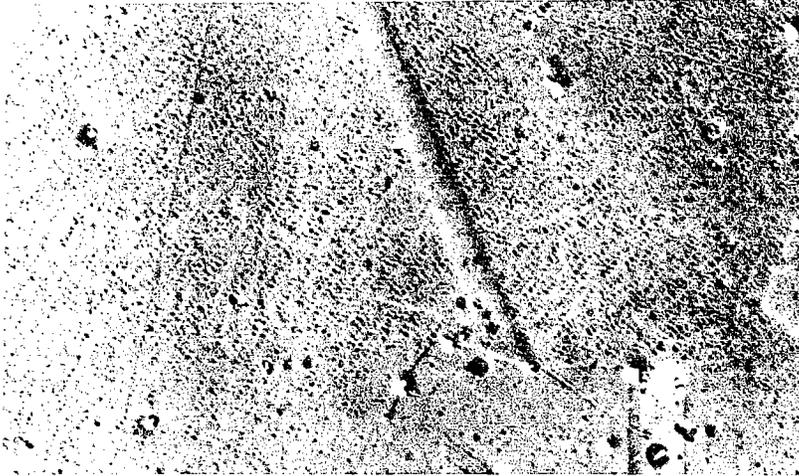
D

Fig. 3 Optical and acoustic comparisons of steel surface

- A. Optical before etching
- B. Optical after etching
- C. Acoustic before etching
- D. Acoustic after etching.



Fig. 4 Comparison of acoustic and optical micrographs of a Co-Ti alloy.

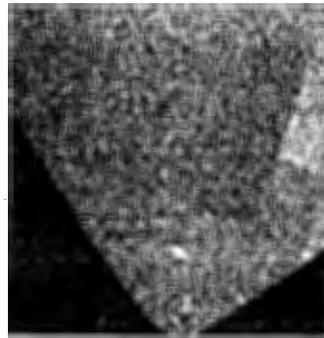


(a)



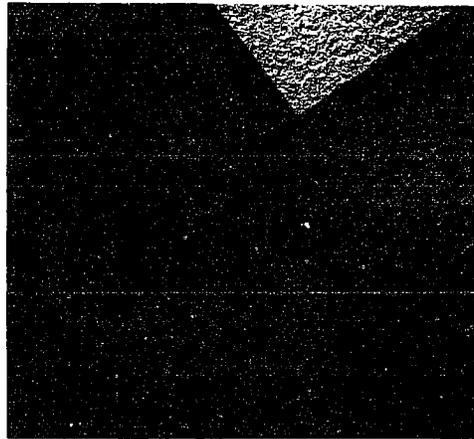
(b)

Fig. 5 Optical (a) and acoustic (b) comparison of polished brass surface.
Field of view is 55 X 90 μm .



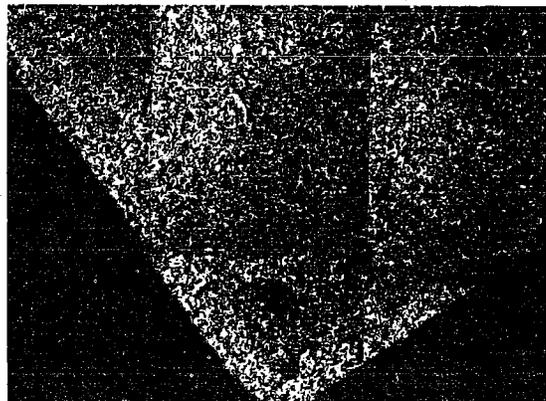
OPTICAL

← 50 μ →



SEM

← 50 μ →



ACOUSTIC

← 50 μ →

Fig. 6 Comparison of optical, SEM and acoustic micrographs of a gold layer on alumina substrate.