Surface Acoustic Wave Microscopy of Optics

CASIS Workshop

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Michael Quarry

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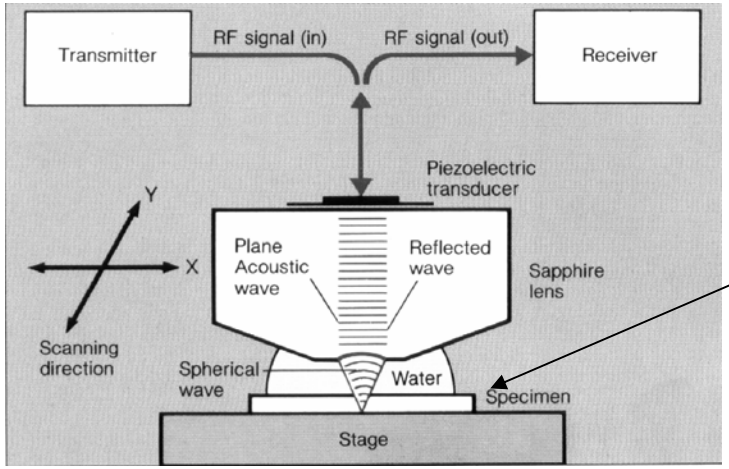
Olympus Surface Acoustic Wave Microscope forms images by raster scanning an acoustic lens over a sample



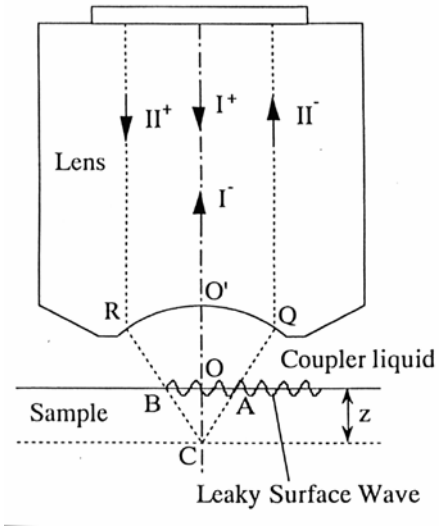
Scan area: 2 mm x 2 mm

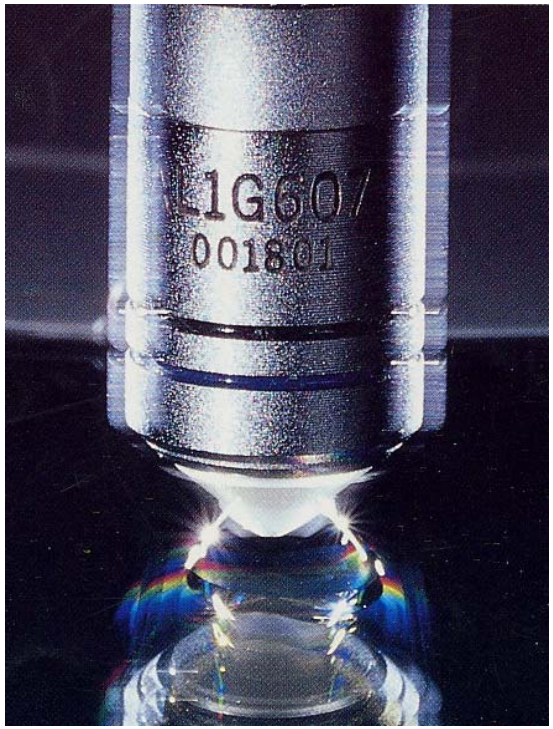
Frequencies: 200 MHz, 400 MHz, 1 GHz

Olympus UH-3 Acoustic Microscope

Acoustic lenses are designed to optimize resolution near the surface

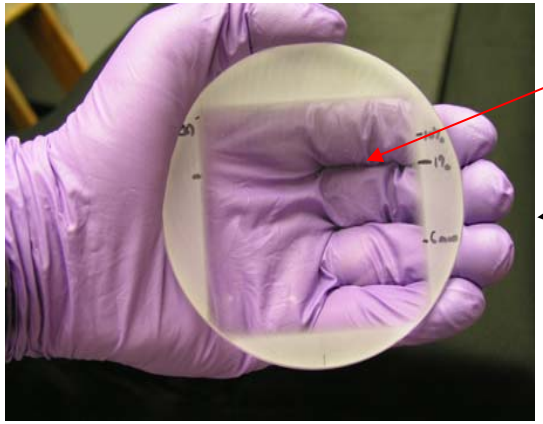
- Acoustic lenses consist of a Sapphire buffer rod with a lens ground and polished into the surface
- Transducer material of ZnO, PZT, or $LiNbO_3$ is deposited on the top of the buffer rod
- Lateral Resolution = $F\lambda$ (3 dB spot-size), F is the f-number and λ is the wavelength
- Olympus transducers designed to focus on the surface and near surface with F = 0.7, focal length ~ 300-500 μm
- Aperture angle is 120 degrees to generate surface waves in most materials





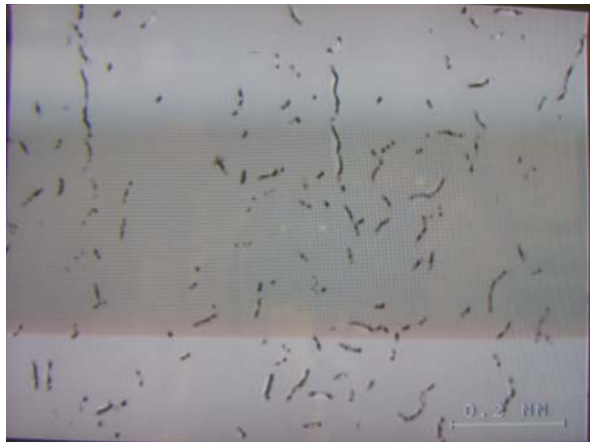
1 GHz
Acoustic Lens

Olympus Surface Acoustic Wave Microscope formed images of surface fractures in fused silica from grinding/polishing

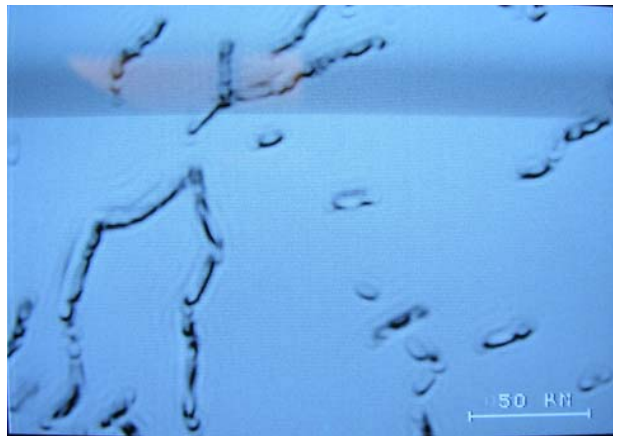


Imaged Area

Corning 7980 Fused Silica after grinding/polishing



1 mm



0.25 mm

400 MHz

Fused silica imaged at 80 MHz with large area scanner

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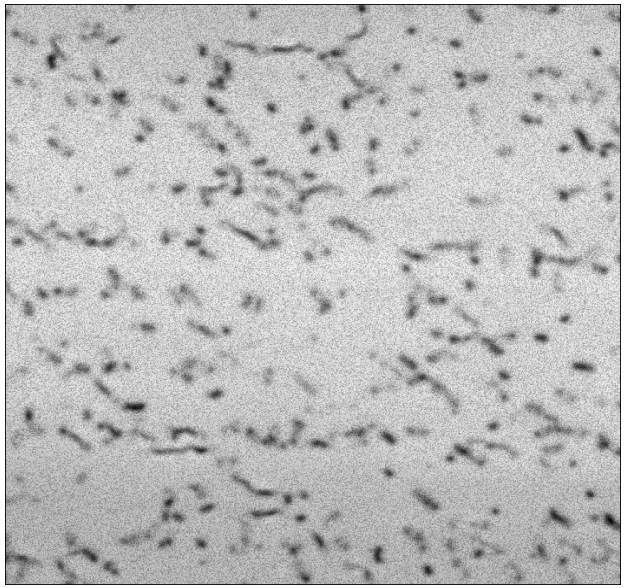
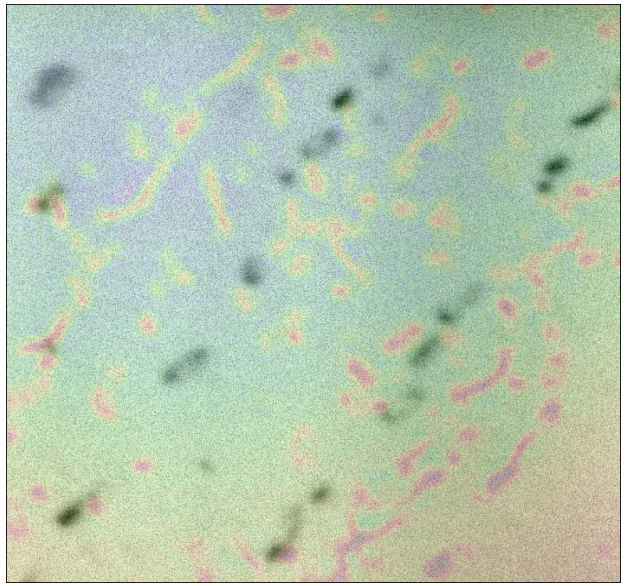
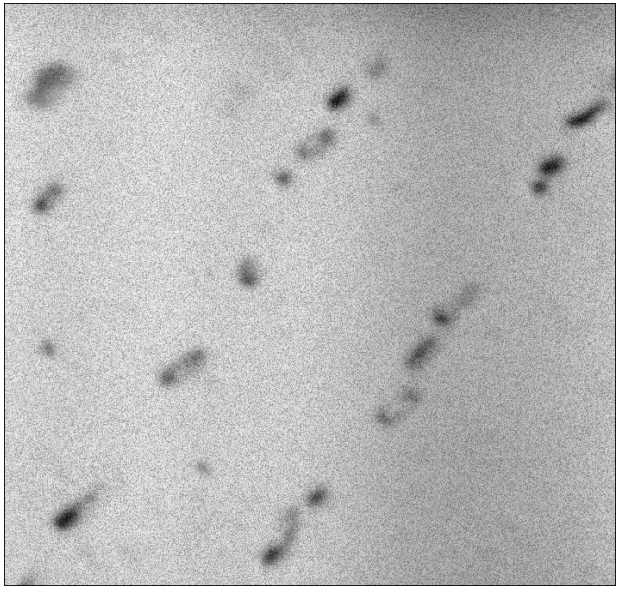
- Large area scanner can scan up to 500 mm by 500 mm
- Frequencies up to 100 MHz with current capabilities
- We plan to incorporate the higher frequency Olympus technology into the large area scanner







1 GHz acoustic microscopy produces resolutions that are comparable to optical techniques

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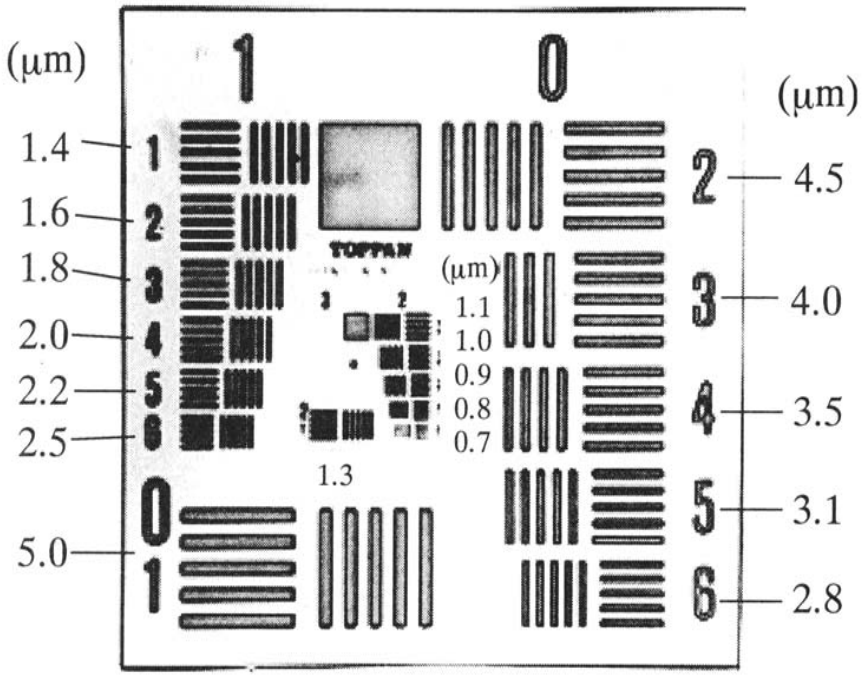
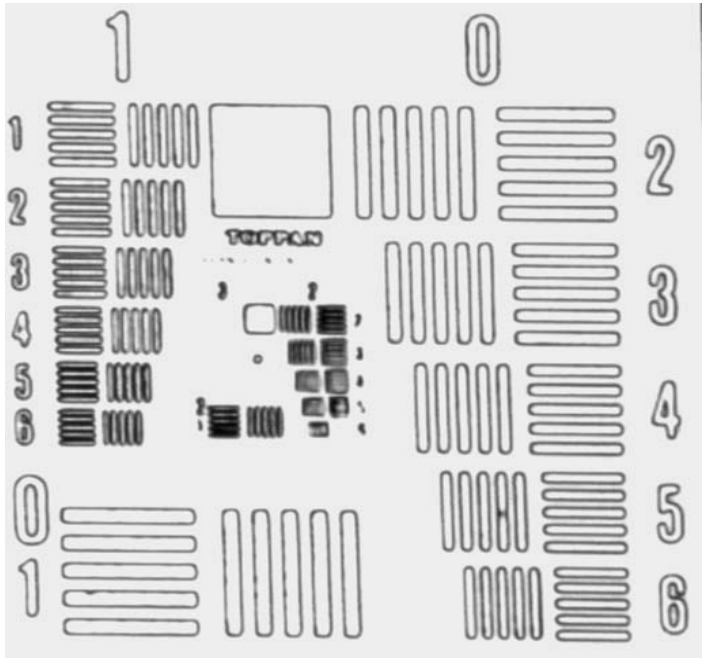
Resolution Test Target



Optical Image

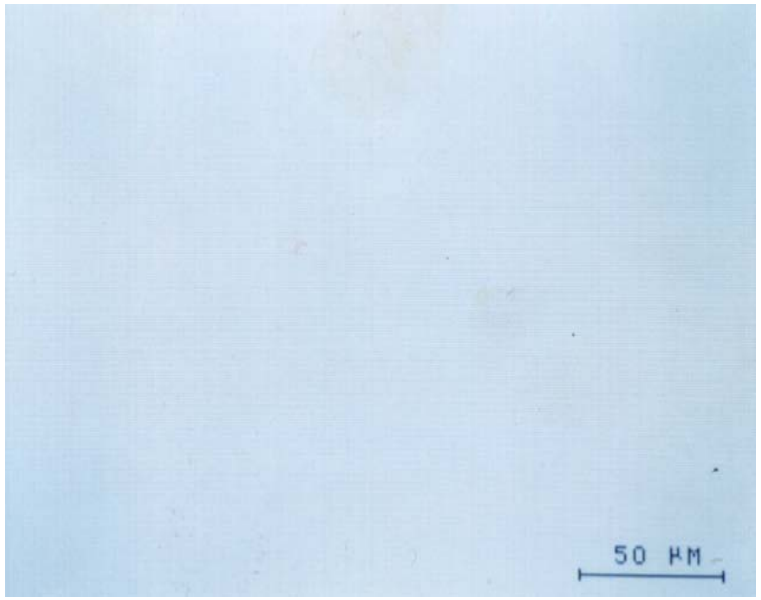


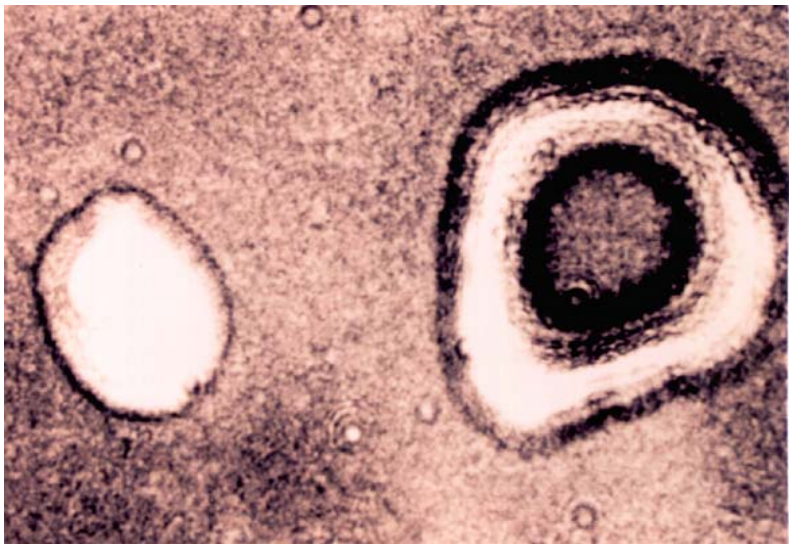
Acoustic Image

(Frequency: 1.0 GHz)

* Courtesy of Chiaki Miyasaka (Penn State)

Acoustic Microscopy detects a void and an inclusion in a polymer coated steel specimen





Optical Image (Surface)

Acoustic Image (Interior)

Frequency: 600 MHz, Field of View: 0.5 × 0.375 mm
Defocusing Distance: Z = - 30 μm

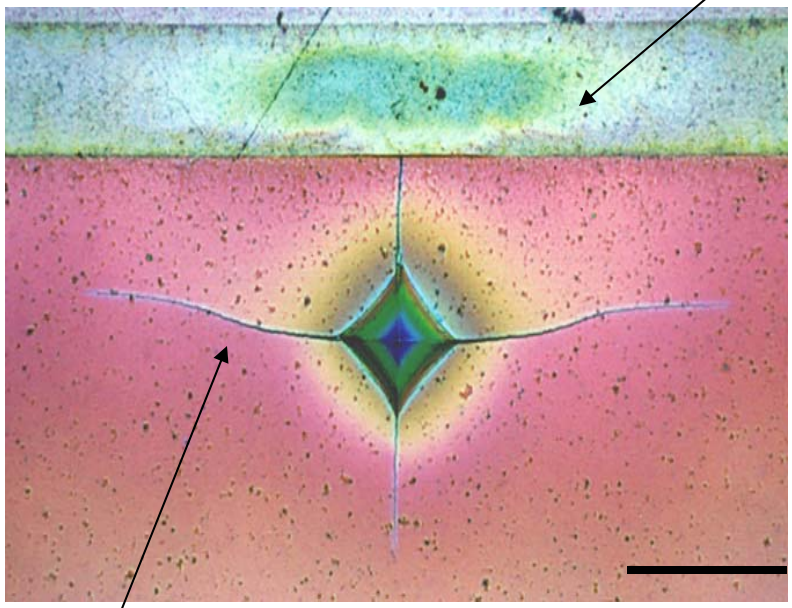
* Courtesy of Chiaki Miyasaka (Penn State)

Scanning Acoustic Microscopy of Si_3N_4/Cu sample with an indentation and delamination at the interface

Example of Flaw (1)

Cu

Si_3N_4

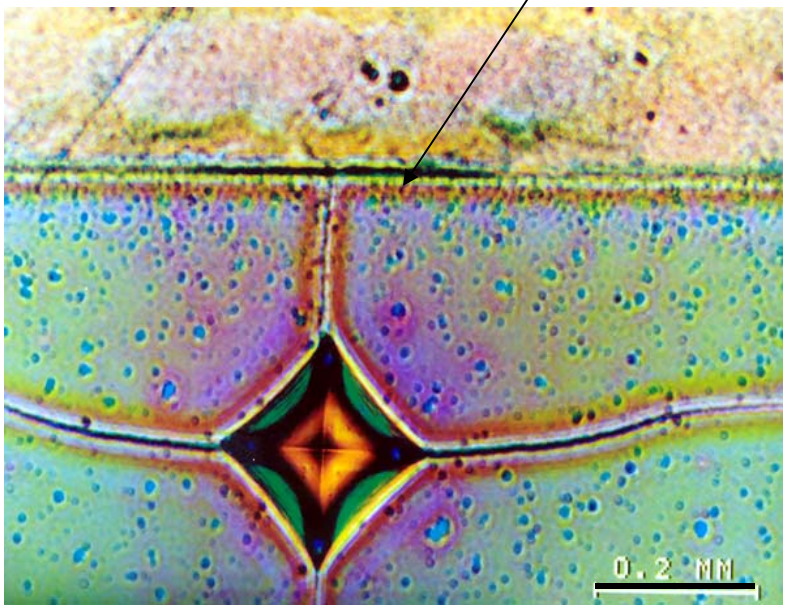


400 µm

Crack

Deformation

Delamination



200 µm

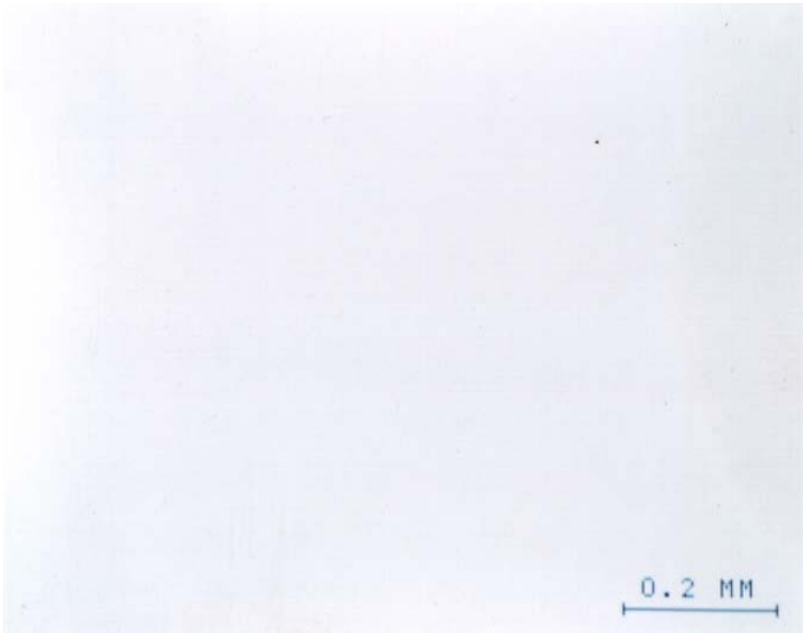
SAM (tone-burst mode) Image

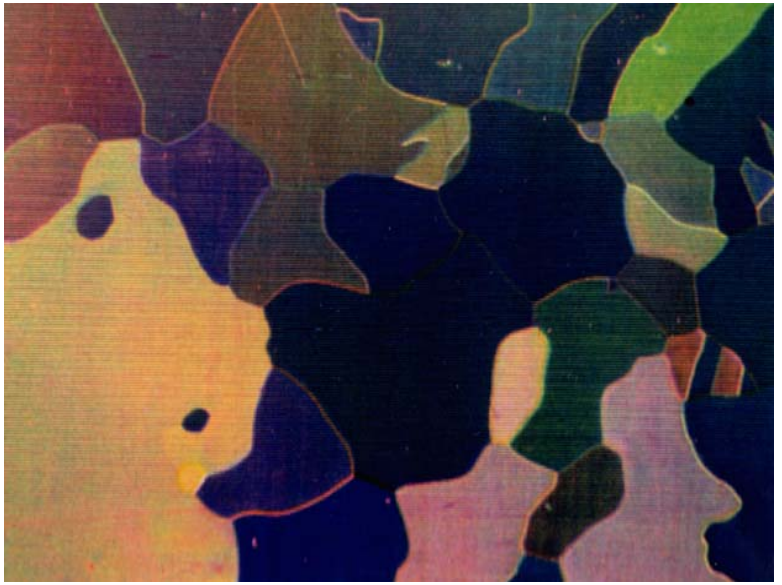
Surface Image

Interior Image

* Courtesy of Chiaki Miyasaka (Penn State)

Grain structure visualization of a polished metal





Optical Image **Acoustic Image**

Surface of Polished Metal (Fe)
Frequency: 600MHz Scanning Size: 1.0 x 0.75mm

* Courtesy of Chiaki Miyasaka (Penn State)

Conclusions

- Acoustic microscopy has been shown to detect 10 μm length cracks from machining and polishing in fused silica
- Cracks will still be observed without etching
- Subsurface cracking and damage can also be detected
- Acoustic microscopy is capable of visualizing grain structures without etching
- Other potential applications including coatings and thin films
- Biological specimens may be observed in a living state because staining is not necessary