ACOUSTO-ULTRASONIC NONDESTRUCTIVE EVALUATION OF MATERIALS USING LASER BEAM GENERATION AND DETECTION

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This work has been supported in part by
NASA/Lewis Research Center
Through NASA Grant #NAG3-728

51

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TO INVESTIGATE THE POSSIBILITY OF USING LASER GENERATION AND DETECTION OF ULTRASOUND TO REPLACE PIEZOELECTRIC TRANSDUCERS FOR THE ACOUSTO-ULTRASONIC TECHNIQUE.
ADVANTAGES OF LASER ACOUSTO-ULTRASONICS

- NON-CONTACT TESTING

- PIEZOELECTRIC TRANSDUCER COUPLING PROBLEMS ELIMINATED
  
  CONTACT PRESSURE

  COUPLANT

  TESTING HOT SURFACES OR IN HOSTILE ENVIRONMENTS

- RESONANCE OF TRANSDUCERS ELIMINATED

- POINT DETECTION

- NARROW AND WIDE BAND DETECTION

- DETECTION NEAR MATERIAL EDGES
DISADVANTAGES OF LASER DETECTION

- SURFACE MUST BE REFLECTIVE
- NOT AS SENSITIVE AS PIEZOELECTRIC TRANSDUCERS
- OPTICAL SYSTEMS ARE OFTEN MORE EXPENSIVE
TYPES OF INTERFEROMETERS USED

- PATH STABILIZED BULK SYSTEM
- HETERODYNE FIBER OPTIC SYSTEM
PATH STABILIZED INTERFEROMETER
HETERODYNE FIBER OPTIC INTERFEROMETER
INTERFEROMETER
SENSITIVITY CONSIDERATIONS

\[ \text{SNR} \propto \left( \frac{R \, P_0 \, \eta}{h \, n \, \Delta \nu} \right)^{1/2} \frac{\delta}{\lambda} \]

- \( h \): PLANCK'S CONSTANT
- \( \lambda \): OPTICAL WAVELENGTH
- \( \eta \): DETECTOR QUANTUM EFFICIENCY
- \( \delta \): SIGNAL AMPLITUDE
- \( \Delta \nu \): DETECTION BANDWIDTH
- \( R \): SAMPLE REFLECTIVITY
- \( P_0 \): LASER POWER
FOCUSING LENS

INTERFEROMETER PROBE BEAM

2024 T4 ALUMINUM

TRANSUDER

3"

ULTRASONIC PULSER

5 MHz PULSE TO TRANSUDER
LASER GENERATION OF ULTRASOUND

KIGRE Nd YAG PULSED LASER

17 mJ PER PULSE

4 ns PULSE LENGTH

3 mm BEAM DIAMETER
NON-CONTACT GENERATION AND DETECTION OF ULTRASOUND IN AN ALUMINUM BLOCK
Theoretical Surface Displacement For Laser Generated Ultrasound In A 1.5 in Al Block On Epicenter
Piezoelectric Detection

Interferometric Detection

Laser Generated Ultrasound (Al Block–On Epicenter)
Theoretical Surface Displacement For Laser Generated Ultrasound In A 1.5 in Al Block 7/8 in Off Epicenter
Piezoelectric Detection

Interferometric Detection

Laser Generated Ultrasound (Al Block-Off Epicenter)
NON-CONTACT GENERATION AND DETECTION
OF ULTRASOUND IN A BRASS PLATE
Piezoelectric Detection

Interferometric Detection

Laser Generated Ultrasound (Brass Plate)
Piezoelectric Detection

Interferometric Detection

Laser Generated Ultrasound (Brass Plate)
FOCUSING LENS

INTERFEROMETER PROBE BEAM

2024 T4 ALUMINUM

GLASS CAPILLARY

3"
Figure 2.
THEORETICAL RECORD OF A STEP-LOADING
POINT SOURCE STRIKING AN INFINITE HALF-SPACE
DIMENSIONS OF SAMPLES USED IN LASER ACousto-Ultrasonic Tests

GR/EPOXY 90 DEGREE LAMINATE

10 in.

0.054 in. thick

GR/EPOXY CROSS-PLY

9 in.

0.046 in. thick

FILAMENT WOUND COMPOSITE

5 in.

0.25 in. thick

(ALL SPECIMENS 0.5 INCHES WIDE)

*3M SILVER POLYESTER FILM TAPE WAS USED AT DETECTION SITES TO INCREASE REFLECTIVITY
Nd YAG PULSE

INTERFEROMETER
PROBE BEAM

FOCUSSING LENS

LASER ACOUSTO-ULTRASONICS
Piezoelectric Detection

Interferometric Detection

Laser Generation (Gr/Epoxy 90 Degree Laminate)
Piezoelectric Detection

Interferometric Detection

Laser Generation (Gr/Epoxy Cross-Ply)
LASER ACOUSTO-ULTRASONICS COMPLEMENTS STANDARD PIEZOELECTRIC ACOUSTO-ULTRASONICS AND OFFERS NON-CONTACT NONDESTRUCTIVE EVALUATION.