Laser-Ultrasound as powerful technology for defect detection and material characterization

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Kurzfassung

Following advances in laser technology and significant methodological developments, laser ultrasound has now become a measurement technique with high potential for problems in non-destructive material testing and characterization. Ultrasonic waves excited with focused laser light propagate in the specimen and are subsequently detected again with a laser vibrometer. Reconstruction algorithms allow inclusions to be located and physical models can be used to determine material properties. The method is non-contact, and flexible laser guidance - e.g. with optical fibers - also allows uneven samples to be scanned robotically and automatically. The potentially in-line-capable measurement technology can thus make an important contribution to increasing the resource efficiency of production processes. Furthermore, a very wide frequency range (industrially suitable typically 500kHz to 50MHz, but also up to the GHz range) is available for evaluation at each measurement point, which enables not only high-resolution defect detection but also new insights into the elastic properties and microstructure of materials even during thermal treatments. In this presentation we show examples of applications starting from in-situ monitoring of metallurgical processes during thermal treatment to the characterization of acoustic wave filters in the GHz-range for wireless communication.

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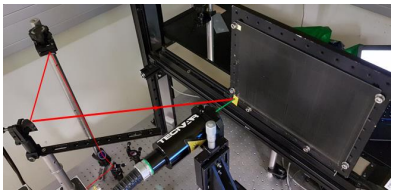
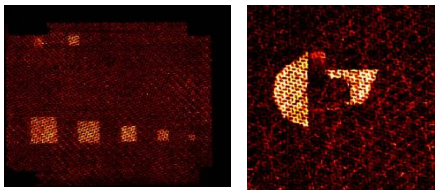
BROAD SPECTRUM OF LASER ULTRASOUND APPLICATIONS

DEFECT DETECTION IN FIBER REINFORCED PLASTIC



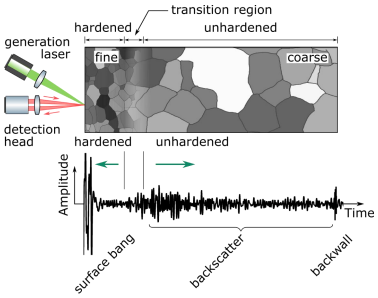
The laser ultrasonic scanning system for CFRP plates moves continuously allowing 100 measuring points per second



Laser ultrasound C-scans showing samples with delaminations induced by incorporated foils (left) and impact damage (right)

Robotized LUS-system with fiberized scan-head for aerospace applications

DETERMINATION OF HARDNESS PENETRATION DEPTH

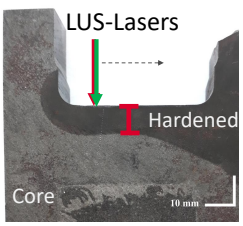


Laser excitation

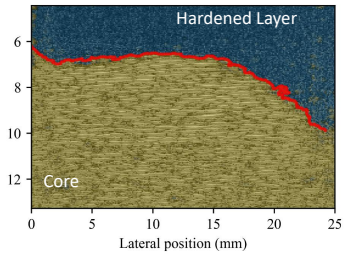
Launch acoustic pulse

Backscattering at coarse grains

Interferometric detection

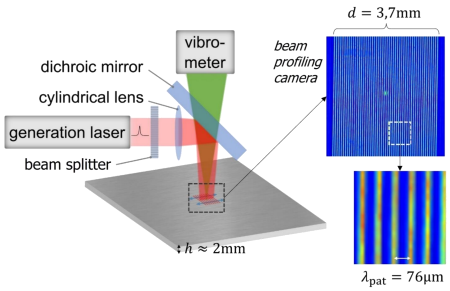


Optical cross section image of a crank shaft



Laser ultrasonic evaluation with hardness penetration depth by machine learning

SINGLE SHOT FULL PLATE CHARACTERIZATION



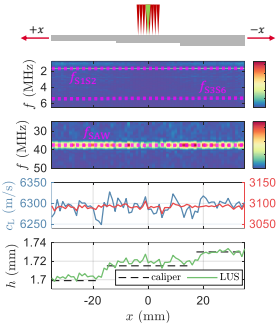
Measurement setup generating a periodic excitation pattern

Periodic pattern couples into

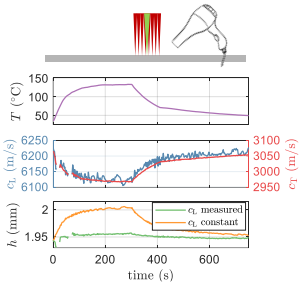
2 plate resonances and

1 surface wave (fixed λ)

sound velocities c_L, c_T *and* thickness h



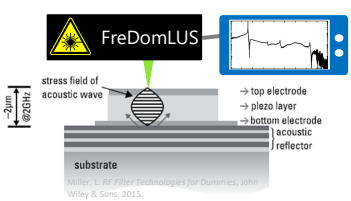
Demonstration with steps in plate (AA7075)



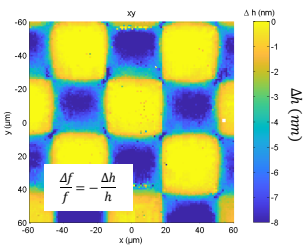
Demonstration with heated plate

CHARACTERIZATION OF GHz RESONATORS AND COMPOUNDS

Thickness mapping based on local resonance frequencies

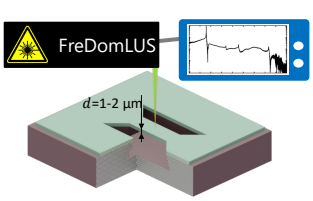


Scan on bulk acoustic wave-resonator

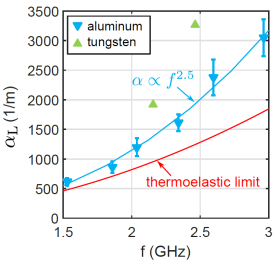


Thickness map

Material loss measurements



Free standing membranes of tungsten and aluminum



Longitudinal attenuations