

1pPA2. Ultrasound propagation in random, two-phase media with application to damage detection in concrete. Joseph A. Turner, Sean P. M. Dugan, and Liyong Yang (Dept. of Eng. Mech., W317.4 NH, Univ. of Nebraska-Lincoln, Lincoln, NE 68588, jaturner@unl.edu)

The scattering of ultrasonic waves in a random two-phase medium, such as concrete, is discussed. Explicit expressions are derived for the attenuation of longitudinal and shear waves in terms of the statistics of the density and Lam parameter fluctuations. The derivation is based upon diagrammatic methods. The problem is posed in terms of the Dyson equation, which is solved for the mean field response. The attenuation results are given here in a straightforward manner. The general description is further simplified in accord with assumptions representative of a random, two-phase material. The medium is assumed statistically homogeneous and statistically isotropic, with a single correlation length. With these assumptions, the attenuations reduce to simple integrals on the unit circle. Expressions for mean free paths and elastic diffusivity follow from the general scattering theory. Applications to diffuse ultrasound experiments in concrete are then discussed. In particular, the appropriate form of the two-point spatial correlation function is examined and compared with experimental results from digitized concrete images. These results show that the assumed form of the correlation function describes the spatial statistics well. Finally, damage detection prospects relevant for concrete inspection are discussed. [Research supported by NSF Grant No. CMS-99-0078707.]

1:30

1pPA3. A crack model for nonlinear wave modulation spectroscopy. Boris Gommerstadt (Northeastern Univ., Boston, MA, 02115 Gommers@coe.neu.edu) and Alexander Sutin (Stevens Inst. of Technol., Hoboken, NJ 07030)

Nonlinear wave modulation spectroscopy is a novel technique for damage and crack evaluation based on the effect of modulation of ultrasonic waves by vibration. This technique was developed as an experimental approach and our goal is to discuss some mathematical models simulating these phenomena. The first model describes variation of resonance frequencies of the ultrasonic wave by breathing crack oscillation under low frequency vibration. This model considers an opened crack with the length changing under the action of vibration. The second model is concerned with plastic deformation in the vicinity of the crack tips that develops a hysteretic stress-strain relationship leading to the increase of ultrasonic wave damping. The Dugdale model is employed to describe ultrasonic wave damping and its variation under the vibration. These models relate modulation parameters to crack size and position. The suggested models explain the basic features of the observed modulation phenomena and could be used for characterization of the dimension and localization of cracks and crack-like damage.

1pPA4. Crack location using nonlinear means applying modulation of ultrasonic pulses by cw vibration. Vyacheslav V. Kazakov (Inst. of Appl. Phys. RAN, Nizny Novgorod, Russia), Alexander M. Sutin (Stevens Inst. of Technol., Hoboken, NJ), and Paul A. Johnson (Los Alamos Natl. Lab., Los Alamos, NM)

Nonlinear wave modulation spectroscopy (NWMS) was recently introduced as a new tool in NDE. This technique employs the nonlinear interaction of ultrasound and vibration in the presence of defects. Vibration changes the contact area within a defect effectively modulating an ultrasonic wave sensing the defect. NWMS has high sensitivity to the presence of cracks and can be a very good tool for a "pass-fail" test but cannot provide the crack location. A new method for locating defects or cracks in a material, presented in this paper, is based on the modulation of ultrasonic pulses by vibration. The cw vibration induces modulation of the signal reflected from cracks. Measurements of the spatial distribution of the modulation level are the basis of nonlinear acoustic imaging. Experimental verification of the method has been conducted in steel plates containing a circular hole and a fatigue crack. The high-frequency (carrier) impulse was about 3 MHz, and the modulating vibration frequency was 5–15 Hz. This technique images a crack very well while a hole was not detected. As the location of damage is the next important issue in NWMS, this work represents an important step. [This work was partially supported by International Science Technical Center, Grant No. 1369.]

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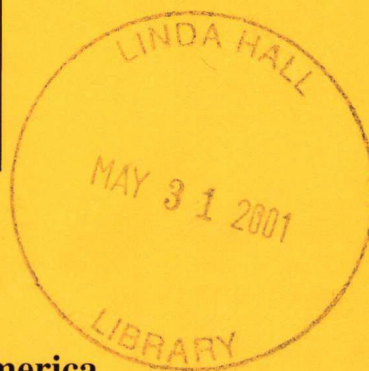
1pPA5. Laser-induced weak shock in fused silica for destructive testing of thin films. Junlan Wang and Richard L. Weaver (Theoretical and Appl. Mech., Univ. of Illinois, Urbana, IL 61801)

Dynamic testing of the adhesion of thin films to solid substrates is a challenging problem. Work of the past decade testing such films by the impact of a compressive stress wave pulse generated by a laser pulse has determined that a critical parameter is the fall time of the stress pulse. Here we report the development of a variation that allows the necessary fall times to be readily achieved. A YAG laser of moderate power (100 mJ) and pulse duration (10 ns) illuminates a 0.4- μ m aluminum layer on a fused silica substrate. A transparent 300- μ m water-glass layer provides an inertial backing. The resulting compressive stress pulse that enters the substrate has a strain amplitude of the order of 2% and a duration of 10 ns. The negative elastic nonlinearity of the fused silica causes this pulse to evolve, over a distance of 1 mm, into a linear ramp followed by a weak shock that has a theoretical fall time of 10 ps. Interferometric measurements of the pulse, and observations of the failure of a micron-thick aluminum layer on the opposite side of the substrate, confirm this understanding. [Work supported by NSF.]

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