Introduction to Special Issue on Nonlinear Ultrasonic Nondestructive Evaluation

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Nonlinear elasticity, and as a result, nonlinear acoustics, has long been known to be sensitive to various mechanical defects in materials. Independently, researchers in the fields of condensed matter and solid state physics, geophysics, medicine, nondestructive evaluation and various engineering disciplines have all studied and exploited nonlinear acoustic phenomena. In particular, the most relevant to this special issue are the abundance of techniques that have been developed for the purpose of monitoring material integrity and for detection, localization and imaging of mechanical defects as well as the study of the mechanisms giving rise to such nonlinear elastic phenomena as classical and non-classical nonlinearity, hysteresis, conditioning and slow dynamics. As the guest editors of this special issue, we are excited to be involved in assembling a snapshot of the current state of the art coming from the disparate disciplines all studying this fascinating topic. It is our hope that by bringing together these disciplines, a cross-pollination of ideas will arise and lead to a better understanding of the

physics and more powerful technologies for the scientific community.

The thirteen articles in this special issue concern a variety of techniques, defects, characterizations and materials. The first two papers, “Frequency Dependence of Second-Harmonic Generation in Lamb Waves” and “Effect of Localized Microstructure Evolution on Higher Harmonic Generation of Guided Waves” each examine critical aspects of nonlinear guided waves. The use of wave mixing techniques is applied to study diffusion bonds and localized plastic strain in “Non-linear Ultrasonic NDE of Titanium Diffusion Bonds” and “Detecting Localized Plastic Strain by a Scanning Collinear Wave Mixing Method,” respectively. The article “Pulse-Echo Harmonic Generation Measurements for Non-destructive Evaluation” presents a model for a single-sided nonlinear inspection technique. The article “Dynamic Acousto-Elasticity in a Fatigue-Cracked Sample” presents a unique way to observe nonlinear elastic features over a wide range of nonlinear behaviors, while “Optimized Dynamic Acousto-Elasticity Applied to Fatigue Damage and Stress Corrosion Cracking” uses the same technique to examine both fatigue and corrosion damage. The paper “Forced Nonlinear Vibrations of a One-Dimensional Bar with Arbitrary Distributions of Hysteretic Damage” examines resonance frequency shifts caused by the damage, while “Resonant Acoustic Nonlinearity of Defects for Highly-Efficient Nonlinear NDE” studies the effect of local defect resonances. Nonlinear spectroscopy is used in “The Application of Nonlinear Reverberation Spectroscopy for the Detection of Localized Fatigue Damage” to detect a single fatigue crack in a linear material. Changes in material microstructure such as recrystallization and thermal degradation are presented in “Discrimination Between Cracks and Recrystallization in Steel Using Nonlinear Techniques” and “Thermal Degradation Evaluation of HP40Nb Alloy Steel After Long Term

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Service using a Nonlinear Ultrasonic Technique,” respectively. Finally, the time shift method is used to examine temperature effects in concrete in the manuscript “Effect of the Temperature on the Nonlinear Acoustic Behavior of

Reinforced Concrete Using Dynamic Acoustoelastic Method of Time Shift.”

Guest Editors