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Wide band time reversal acoustic nonlinear diagnostics

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Time reversal acoustics (TRA) techniques provide a means to focus energy at a localized time and space, or at an unknown location (i.e., source or scatterer not known a priori) without the need to calculate time delays, as is necessary for phased arrays. The experiments demonstrate that time reversal focusing provides localized surface vibration with amplitude sufficient to induce measurable nonlinear effects and does so over a wide frequency band. Because the amplitude is spatially focused, time reversal enables local probing of this nonlinearity that can be used for nonlinear imaging. The nonlinear effects for wide band frequency signals were measured by phase-inversion method combining two signals of opposite sign in order to cancel the linear response and preserve quadratic nonlinearities. The method works effectively for nonlinear NDE of thin plates where laser Doppler Vibrometer can be used for measurements of the surface vibration and TRA focusing of acoustic waves. Presented results include crack and delamination diagnostic in epoxy graphite composites, diffusion bonded metallic disks and impact surface damage in glass. Scanning electron microscopy and optical images are also shown to demonstrate the types of damage features detected using this method.