Nonlinear ultrasonic diffuse field spectroscopy

Jack Potter[1]

[1]N/A, Verasonics, United Kingdom

Nonlinear ultrasonic diffuse energy imaging is a method for measuring elastic nonlinearity by contrasting the statistical diffuse energy of fields focused through sequential and parallel beam forming. Regardless of the underlying mechanics, the effect of elastic nonlinearity on an ultrasonic field is the movement of energy away from the transmission bandwidth. Consequently, the original implementation of this imaging method evaluated the energy flux from the transmission bandwidth. This metric is broadly sensitive to elastic nonlinearity but is not selective. Analysis of the full diffuse spectra allows the movement of energy to specific frequency components to be evaluated. From this, the nature of elastic nonlinearity can be characterized. Experimental studies on fatigue cracks show increases in both super-harmonic and the difference-frequency modulation of the excitation bandwidth. Further, it is demonstrated that measurement of these components of the diffuse spectra can be used to generate spatial maps of elastic nonlinearity. Unlike coherent scattering approaches to nonlinear imaging, the spatial resolution of diffuse energy methods is determined by the transmission frequency, not the measured frequency component. Low frequency components can therefore be used to generate high resolution nonlinear images. The principal limitation of nonlinear diffuse energy has been the size of structure to which it can be effectively applied. Larger structures require longer for a statistical diffuse state to be reached, eventually resulting in the field becoming immeasurable. However, the very low frequency components generated through difference-modulation persist for much longer, making this approach applicable to larger structures than is possible with fundamental frequency diffuse energy imaging.