Sudden structural failure is a severe safety threat to many types of military and industrial composite structures. Because sudden structural failure may occur in a composite structure shortly after macroscale damage initiates, reliable early diagnosis of microdamage formation in the composite structure is critical to ensure safe operation and to reduce maintenance costs. Ultrasonic guided waves have been widely used for long-range defect detection in various structures. When guided waves are generated under certain excitation conditions, in addition to the traditional linear wave mode (known as the fundamental harmonic wave mode), a number of nonlinear higher-order harmonic wave modes may also be generated. Research shows that the nonlinear parameters of a higher-order harmonic wave mode could have great sensitivity to microstructural changes in a material. In this work, we successfully employed a nonlinear guided wave structural health monitoring (SHM) method to detect microscopic impact damage in a 32-layer carbon/epoxy fiber-reinforced composite plate. Our effort has demonstrated that, utilizing appropriate transducer design, equipment, excitation signals, and signal processing techniques, nonlinear guided wave parameter measurements can be used to monitor microdamage growth in composite panels.

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