In-situ Fabricated Piezoelectric Film Ultrasonic Transducers for Evaluating Plastic Deformation of Alloy Structures

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The mechanical stress that exceeds the yield limit of materials generates permanent damage and may induce serious accidents. A reliable non-destructive testing technique that allows examination of plastic deformation of metallic structures is therefore highly demanded. The work about a nonlinear ultrasonic method for evaluating yielding of aluminum (Al) and titanium (Ti) alloy structures using in-situ fabricated piezoelectric film ultrasonic transducers will be presented.

The in-situ fabricated piezoelectric ultrasonic transducers are designed and produced for investigating plastic deformation of the metallic alloy structures with second harmonic Rayleigh ultrasonic waves. The transducers, made of piezoelectric polymer coating and comb-shaped electrodes are directly integrated on the Al and Ti alloy specimens with direct-write process. The Rayleigh ultrasonic waves, generated by the direct-write transducers and propagating along the structures, are measured by using a laser scanning vibrometer or the direct-write transducers to obtain the acoustic nonlinearity parameter, and to determine the relationship between the acoustic nonlinearity and plastic deformation.

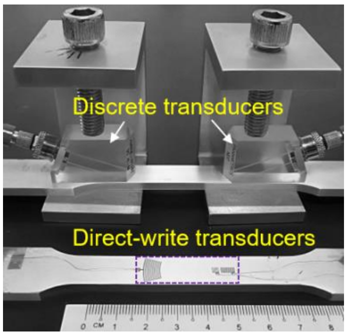

Fig. 1. Comparison of discrete transducers and direct-write transducers for acoustic nonlinearity measurement.

The experimental results demonstrate that the in-situ fabricated piezoelectric ultrasonic transducers can successfully determine the plastic deformation of both Al and Ti structures, with the acoustic nonlinearity increasing with plastic strain. The two alloy specimens with different plastic deformation are further evaluated with optical microscopy, scanning electron microscopy, transmission electron microscopy and X-ray diffraction to investigate acoustic nonlinearity resulting from micro-structural changes. According to the results and analyses, the use of in-situ fabricated piezoelectric ultrasonic transducers can substantially improve the measurement reliability and consistency by eliminating the repeatability issues due to the transducer misalignment, inconsistent fixing force and acoustic coupling agents in the use of the conventional discrete angle beam transducers (Fig. 1). Therefore, the implementation of the direct-write piezoelectric transducers has significant technical advantages and is promising for applications in yielding evaluation of structural materials with acoustic nonlinearity.