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Application of Anti-Symmetric Flexural Modes for the Detection of Moisture.

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Abstract

This research focus on exploring the effects moisture absorbed by a layer of hygroscopic film coated on the wedge tip along that anti-symmetric flexural (ASF) modes propagate. A shear wave transducer is applied to measure the signals of wedge wave propagating along the wedge tips. Velocity of the ASF mode is indicated to decrease while the moisture is absorbed by the hygroscopic film. Also, the amount of velocity reduction is indicated to be increasing as the moisture increases. Results of the current research suggest the ASF modes can be a new candidate for the application of acoustic sensor to detect moisture.

Keywords : wedge wave, ASF mode, transducer, coating, hydroscopic film, moisture.

1. Introduction

Surface acoustic wave (SAW) is one of the acoustic waves often bringing to acoustic sensors. The mechanism of mass loading effect is frequently used to measure gas, chemical or biological [1].

Wedge wave is discovered by Lagasse [2, 3] in the early 1970's through a numerical study. The wedge wave is guided acoustic waves that propagate along the wedge tip, and their energy is tightly confined near the apex. Wedge wave with a displacement field that is anti-symmetric about the mid-apex plane are called ASF modes. Fig. 1 shows the wedge wave motion pattern of an ASF mode. The exact value of wedge wave velocity hasn't been solved up to now. By assuming the wedge to be a thin plate of variable thickness, McKenna et al. obtained a theoretical approximation for the prediction of the dispersion relation of a truncated wedge. [4] Also, Krylov used a geometric acoustic approximation [5, 6] to obtain the phase velocity of ASF modes. Experimental works employing piezoelectric transducers, miniature non-contact electromagnetic acoustic transducers (EMAT) [7] and [8] and laser ultrasound techniques [9~11] have been conducted to investigate different aspects of ASF modes, including the influences of apex angles, apex truncation [10], fluid loading effects, and the effect of curvature of the wedge apex[11]. For a flat substrate, the effects of a thin film coating on the propagating behaviors of guided waves are well known, however, not for the case of ASF modes .Until 2007, Tang and Yang successfully combine the LUT & FEM to observe dispersion behaviors of wedge coated with a metallic film [12].

This paper describes an experimental investigation for the velocity variation of ASF modes propagating along wedges with a coating hygroscopic film in different moisture.

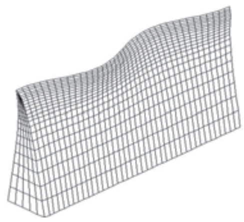

Fig. 1 Wave motion pattern of an ASF mode

2. Material and Sample

Fig. 2 is the schematic showing the position for one side of a wedge coated with a hygroscopic film. The sample is an aluminum substrate wedge coated with polyvinyl alcohol (PVA) film. The apex angle (θ) is 60° and truncation (H) is controlled within 10 μm to avoid divergence of velocity. The thickness (t) of film is 48μm. The wedge length (L) is 25.4mm. The Notation of specimen is designated as AlPVA60.

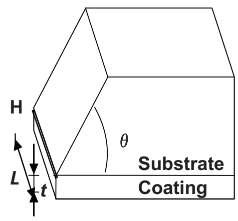

Fig. 2 Geometry of a specimen

3. Experimental setup

As shown in Fig. 3, the experimental configuration consists of a shear wave transducer and a plus receiver for ultrasonic wave generation and detection. The central frequency of transducer is 5MHz. An oscilloscope is responsible for examining the discrepancy of velocity from wedge wave signal. Moisture is controlled by an atomizer in a water-repellent chamber.

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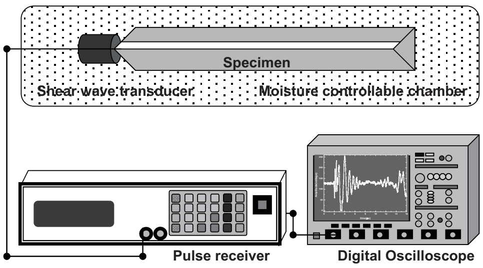

Fig. 3 Experimental configuration

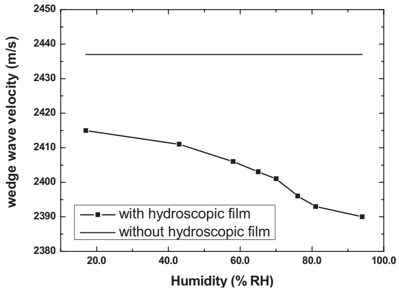

Fig. 6 Non-coated compare with coated

4. Results and Discussions

Fig. 4 shows measured ultrasonic signal of wedge without coating. Using formula of V=2L/Δt be confirm the signal of A and B were surface wave and wedge wave. Where V, L, and Δt are the velocity, distance and duration of wave propagation. Fig.5 shows the signal of coated wedge under different moisture. The duration of wedge wave propagation increases while moisture increases. That is to say the velocity of the ASF mode decreases while the moisture is absorbed by the hygroscopic film. Mass loaded phenomenon are also observed for the ASF modes in coated wedges. Furthermore, as shown in the Fig.6, the amount of velocity reduction is founded out to be increasing as the moisture increases.

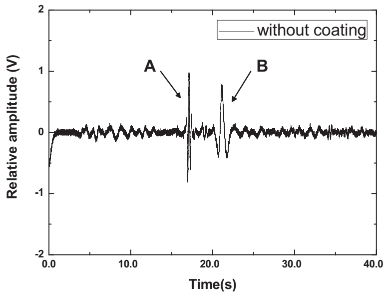

Fig. 4 Ultrasonic signal of wedge without coating

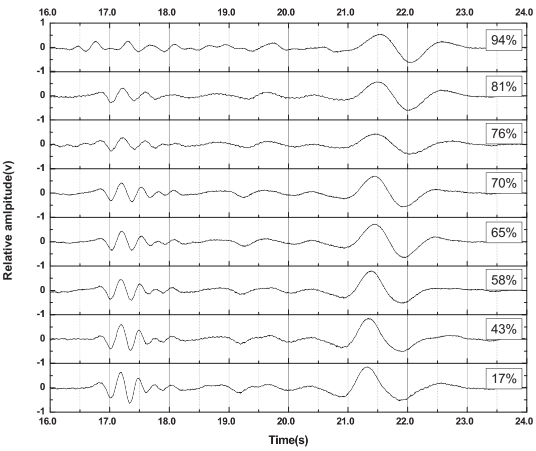

Fig. 5 Ultrasonic signal with different humidity

5. Conclusions

In this research the effects moisture absorbed by a layer of hygroscopic film coated on the wedge tip are characterized for ASF modes propagating along the wedge with an experiment. Velocity of the ASF mode is found to decrease while the moisture is absorbed by the hygroscopic film. Also, the amount of velocity reduction is found out to be increasing as the moisture increases. Results of the current research suggest the ASF mode can be a new candidate for the application of humidity sensors, and possibly biomedical sensors as well.

Acknowledgment

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