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Dispersion Behaviors of ASF Modes Propagating Along Wedge Tips Coated with Hygroscopic Film with Various 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 laser ultrasound technique is applied to measure dispersion spectra of modes propagating along the wedge tips. 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 frequency increases. Results of the current research suggest the ASF mode can be a new candidate for the application of humidity sensors.
Keywords : wedge wave, ASF mode, laser ultrasonic technique, coating, dispersion, humidity.

1. Introduction

Surface acoustic wave (SAW) sensors are frequently used as physical, chemical or biological sensors [1]. Discovered by Lagasse [2, 3] in the early 1970's through a numerical study, Wedge wave are guided acoustic waves that propagate along the tip of a wedge, and their energy is tightly confined near the apex. Like Lamb waves, WWs with a displacement field that is anti-symmetric about the mid-apex plane are called ASF modes. 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] and [6] to obtain the phase velocity of ASF modes. Experimental works employing piezoelectric transducers, miniature noncontact 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. This paper describes an experimental investigation for the dispersion behaviors of ASF modes propagating along wedges with a coating hygroscopic film in different moisture.

2. Material and Sample

Fig. 1 shows the geometry of a wedge coated with a layer of thin film. The sample is an aluminum substrate wedges coated with Polyvinyl alcohol (PVA) film, designated as AlPVA40.

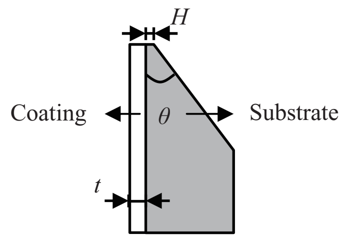

Fig. 1 geometry of a coated wedge.

3. Laser Ultrasonic Measurements

As shown in Fig. 2, the experimental configuration consists of a pulsed laser for ultrasonic wave generation and a laser optical probe to detect the acoustic waves. The excitation source is a Nd: YAG laser with a power of approximately 100mJ, a wavelength of 532 nm, and a pulse duration of 6.6 ns. A Doppler laser optical receiver is applied to detect the ASF modes propagating along the tips of wedges. A B-scan scheme is used for the measurement of the dispersion behaviors of WWs. During scanning, the optical detector is located at a fixed point, while the generation laser beam is scanned along the wedge tip. A two-dimensional fast Fourier transform, first taken with respect to time and then with respect to the scanned position, is used to obtain the dispersion relation from the B-scan data.

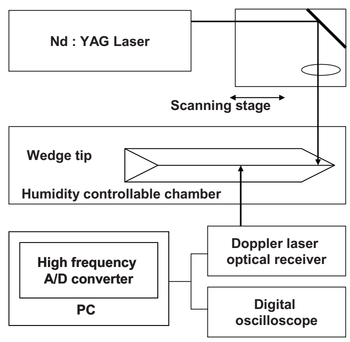

Fig. 2 experimental configuration

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4. Results and Discussions

Fig. 3 shows measured first ASF mode labeled as CA1 for the AlPVA40 sample under different humilities. With the film of slower velocity, the ASF dispersion behaviors are obvious, while the apex truncation of the wedge is small. ASF velocities for the coated wedge start at the ASF mode of the same order for the substrate wedge at the low frequency regime, and gradually influenced by the coating while frequency increases. Like the case of surface acoustic waves propagating along a flat surface with thin coating, mass loaded phenomenon are also observed for the ASF modes in coated wedges. As shown in Fig. 4, with the PVA as a hygroscopic material, the humidity absorbed by the film increases the mass loading effect and reduces the ASF velocity.

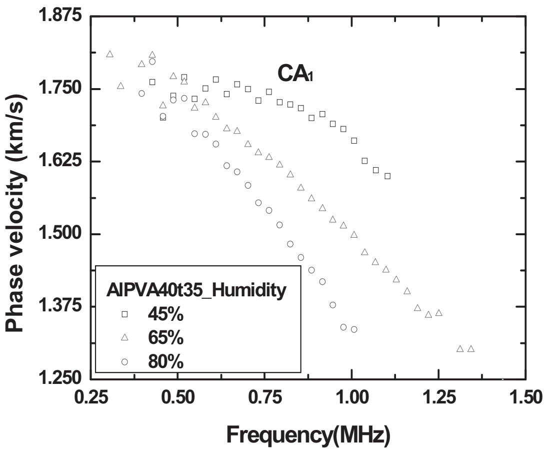

Fig. 3 The CA_1 mode in various humidity

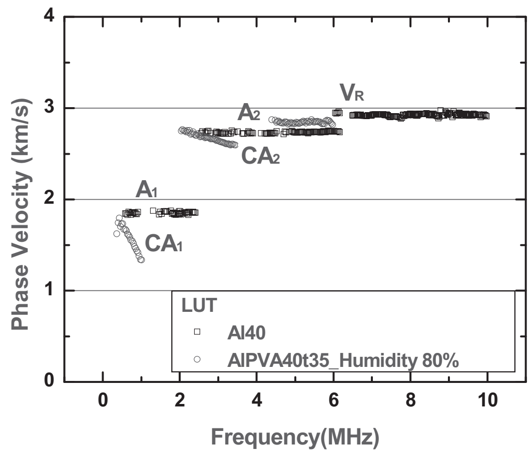

Fig. 4 Dispersion spectra of the AlPVA40 sample

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 a laser ultrasound technique. 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 frequency 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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References

1. Talbi, F. Sarry, M. Elhakiki, and L. Le: Sens. Actuators A. **128** (2006) 78-83.
2. P. E. Lagasse: Electron. **8** (1972) 372.
3. P. E. Lagasse, I. M. Mason, and E. A. Ash, IEEE Trans. Sonics Ultrason. **20** (1973) 143-154.
4. J. McKenna, G. D. Boyd, and R. N. Thurston, IEEE Trans. Sonics and Ultrasonics, **21** (1974) 178-186.
5. V. V. Krylov and A. V. Shanin: Sov. Phys. Acoust. **37** (1991) 65.
6. V. V. Krylov and D. F. Parker: Wave Motion. **15** (1992) 185.
7. J. R. Chamuel: J. Acoust. Soc. Am. **95** (1994) 2893.
8. J. R. Chamuel: in Review of the Prog. Quant. Nondestr. Eval. **16** (1997) 129.
9. X. Jia and M. de Billy: Appl. Phys. **61** (1992) 2970.
10. C.-H. Yang and K.-Y. Tsai: Jpn. J. Appl. Phys. 43 (2004) 4392.
11. C-.H. Yang and J.S. Liaw: Jpn. J. Appl. Phys. 39 (2000) 2741.