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Detection of Molecular Films by Harmonic Generation of Dispersive Rayleigh Waves

by

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Summary

We have applied the technique of thin film detection by harmonic generation of dispersive Rayleigh waves[1] to detect molecular layers of arachidic acid and Ti diffused layers on $LiNbO_3$ substrates. The technique is based on the phase mismatch between the fundamental of a Rayleigh wave and its second harmonic due to the loading of a thin film on an ideal substrate. This phase mismatch causes sinusoidal oscillation of the second harmonic intensity as a function of interaction length. Using an optical probe to measure the diffracted light by the surface wave second harmonic along the propagation direction, the phase mismatch and the associated velocity variation between the fundamental and the second harmonic due to the film can easily be measured.

With an interdigital transducer at 170 MHz, we have observed the acoustic velocity variation ($\Delta v/v = 8 \times 10^{-4}$) due to the loading of six molecular layers of arachidic acid (about 156Å in thickness) on a $LiNbO_3$ substrate. The measurement arrangement is shown in Fig. 1 where half of the $LiNbO_3$ substrate is covered with the arachidic acid film. The intensities of the second harmonic with and without the film are measured by the optical probe as a function of distance from the input transducers. As shown in Fig. 1, the second harmonic intensity in the region without the film grows exponentially and saturates, while the second harmonic under the film oscillates. By the periodicity of the oscillation, the velocity variation can be determined. By varying the substrate temperature, the change of the elastic property of molecular layers through the phase transition can be measured.

The same technique is applied to detect the acoustic velocity perturbation of Ti-diffused layers in $LiNbO_3$ substrates which have been studied for thin film optical waveguides.[2]

In this paper, the basic principle and sensitivity of the measurement technique will be discussed. Experimental results and theoretical calculations based on coupled mode theory will be included. Some possible applications for nondestructive testing of thin film mechanical properties will be described.

1. E. G. Lean and C. G. Powell, Applied Physics Letters, Vol. 19, No. 7, pp. 356, November 1971.

2. R. V. Schmidt, Applied Physics Letters, Vol. 27, No. 1, pp. 8, July 1975.