MEASURING THE THICKNESS AND ELASTIC PROPERTIES OF ELECTROACTIVE THIN-FILM POLYMERS USING PLATE WAVE DISPERSION DATA

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ABSTRACT

Electroactive thin-film polymers arc finding a significant increase in use for sensors and actuators as well as application for muscle mechanisms and micro electro mechanical systems (MEMS). The actuation is attributed to piezoelectric, electrostrictive or electrostatic effects and the films are used in the thickness range of tens to hundreds of microns. Under the application of an electric field the material change its thickness linearly in piezoelectric materials and as function of the field-square in electrostrictive materials as well as under the effect of electrostatics. In addition, the film vibrates as a structure. Measuring the thickness and the thickness change under activation of an electric field and distinguishing between the thickness value and the film vibration amplitude is a complex and costly problem. Most methods, such as interferometry, eddy-current and capacitance, are measuring the location of the top surface of the film assuming that the rear surface stays stationary. Unfortunately, the determination of the actual thickness of thin films or the simultaneous determination of the position of both surfaces of the film cannot practically be made with conventional methods.

Ultrasonic pulse-echo offers an ideal tool for simultaneous determination of the location of the top surface, i.e., vibration amplitude, and the film thickness. However, to obtain an acceptable resolution for 50 to 100-micron thick films it is necessary to use frequencies in the range of 50-MHz and above, which is beyond the capability of conventional ultrasonic systems. Plate wave measurements offer the capability to determine the thickness of thin films using much lower frequencies and to obtain significantly higher resolution. Further, using dispersion curve measurements one can also determine the elastic constants of the film and thus providing important properties that characterize the efficiency of electroactive polymer films. The technique is based on a pair of transmitter/receiver transducers in a pitch-catch arrangement. The specimen film is immersed in silicon oil as a coupling medium and an acoustic wave that is launched in a CW mode is monitored by the receiver. The amplitude spectra of the reflected wave as a function of frequency is used to determine the dispersion curve of the leaky guided generated by the specimen. The dispersion curves are strongly affected by the film thickness and its elastic properties.