Si-Monolithic Miniature Ultrasonic Sensor Using PbTiO$_3$ Thin Film Prepared on a Si or SiO$_2$ Cantilever

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A miniature ultrasonic sensor has been developed by depositing PbTiO$_3$ thin film on a tiny cantilever fabricated on Si wafer. The cantilever is thin Si or SiO$_2$ plate of several tens to several hundreds of microns in length and a few tens to a few hundreds of microns in width. The PbTiO$_3$ film was deposited on the plate by rf or rf magnetron sputtering, and the deposition on Si was improved by using fluoride thin film as a substrate, by applying bias voltage to the substrate or by adding a microwave to the plasma. The fabricated device responds to an ultrasonic wave at several kHz to 150 kHz, and the typical sensitivity and the quality factor are -102 and 290 dB at 35 kHz, respectively.

1. Introduction

Recently, much attention has been paid to ultrasonic sensing technology in many application fields such as structural characterization of materials, medical diagnostics, ultrasonic microscopes and remote control systems because contactless and nondestructive sensing of location, velocity and mechanical properties can be easily made. This is due to the fact that an ultrasonic wave propagates slowly and is diffracted widely in comparison with light which is used in various sensings. It is desired that these sensings be automated extensively and then the sensor can be combined easily with a microcomputer. The development of an excellent sensor having signal processing, a so-called intelligent (smart) sensor, is needed for the sophisticated application using a microcomputer. A typical and conventional sensor in air (microphone) is a piezoelectric ceramic plate such as PZT and PbTiO$_3$ having