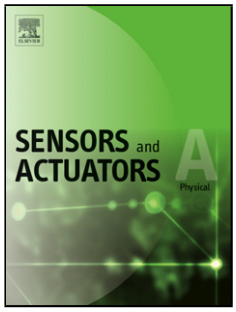

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<AT>Fabrication of Capacitive Micromachined Ultrasonic Transducers with Low-Temperature Direct Wafer-Bonding Technology

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<ABS-HEAD>Highlight ► We present the first demonstration of CMUTs fabrication less than 350℃. ► Characterization results of a prototype CMUT array show good performance and high uniformity. ► The needed temperature reduces from 1050 ℃ for previous wafer-bonding technologies down to 350 ℃. ► The reduced fabrication temperature decreases the thermal stresses and thermal deflection. ► The parasitic capacitance is further reduced since no adhesion metal layer is used. ► The main stress and deflection caused in the process of fabrication are analyzed through FEM.

<ABS-HEAD>Abstract

<ABS-P>In this paper, the low temperature direct wafer-bonding technique under 350 ℃is used to fabricate the capacitive micromachined ultrasonic transducers (CMUTs) and the first illustration of CMUTs with a 15×15 array is obtained. In comparison with other wafer-bonding technology under high temperature beyond 400 ℃, the thermal stress and thermal deformation of CMUTs produced in the wafer-bonding process can be decreased largely because of low bonding temperature. What's more, the low temperature direct wafer-bonding technique is beneficial to combine the CMUTs chip with integrated circuits (ICs) as well as reduce the parasitic capacitance. Based on the low temperature direct wafer-bonding process, a silicon-on-insulator (SOI) wafer with the silicon device layer used for transducer membrane and a low-resistivity silicon substrate with the structured SiO_2 layer are bonded to fabricate the main structure of CMUTs. Therefore, the parasitic capacitance of CMUTs can be further reduced since there is no metal auxiliary layer existing during the bonding process. The structure morphology and electrical characterization of fabricated CMUTs are tested in this paper. Then, the impedance-frequency curve and the corresponding phase-frequency curve of the CMUTs are obtained perfectly, which demonstrate that the fabricated CMUTs based on the low-temperature direct wafer-bonding technique present the fine mechanical and electrical characteristics.

<KWD>Keywords: CMUTs; low temperature direct wafer-bonding; parasitic capacitance; thermal stress; thermal deflection.

Introduction

Micromachined ultrasonic transducers (MUTs) have been used to replace conventional ultrasonic transducers based on bulk piezoelectric material in the past twenty years, and both capacitive micromachined ultrasound transducers (CMUTs) and piezoelectric micromachined ultrasound transducers (PMUTs) are studied by many researchers. Compared with the conventional ultrasound