RF-sputtered ZnO as a Dielectric Material for MEMS Acoustic Sensor

Mahanth Prasad and Vinod Kumar Khanna

MEMS & Microsensors Group, CSIR-Central Electronics Engineering Research Institute, Pilani–333031 (Rajasthan), India

E-mail: mahanth.prasad@gmail.com

Abstract

Zinc oxide (ZnO) films have played an important role in the field of microelectromechanical systems (MEMS) due to their piezoelectric and dielectric properties. These films have excellent compatibility with various substrate materials. ZnO films have been used in the development of various MEMS devices such as film-bulk acoustic-wave-resonators, surface-acoustic-wave resonators, and acoustic sensors [1]. Different techniques have been developed for deposition of high-quality ZnO films such as plasma-enhanced chemical vapor deposition (PECVD), vacuum sputtering, molecular beam epitaxy, pulsed laser deposition and metalorganic chemical vapor deposition. In the present work, the electrical properties of ZnO films deposited by reactive sputtering have been investigated for application in MEMS acoustic sensors. These sensors are used for high sound pressure level measurements between 120 dB to 180 dB in the frequency range 30 Hz to 8 kHz. The sensors comprise two capacitors made with ZnO dielectric film fabricated on a thin silicon diaphragm. In order to achieve maximum sensitivity, one capacitor is fabricated on center area of the diaphragm whereas the other capacitor is fabricated on the outer area of the diaphragm. In this device structure, the ZnO layer is sandwiched between two aluminum electrodes covered with thin PECVD silicon dioxide layer. The sensitivity of the sensor was measured and found to be 380 μV/Pa [2]. The long-term repercussions of relative humidity on capacitance and dissipation factor tan δ were studied in different conditions of etched ZnO layer. The fabrication of the capacitor was done by etching a ZnO layer in the presence of strong acid (HCl) and weak acid (NH_4Cl with electrolytically-added Cu ions), separately [2]. The effects of humidity on capacitance over a long period of time were studied. It was observed that the capacitance values were 1.5 times higher than the original values in the case of strong acid where ZnO layer is exposed to atmosphere due to non step coverage. The corresponding loss tan δ was found to increase from 0.03 to 0.06. However, under the same conditions, the capacitance values did not change in case of weak acid due to proper step coverage. The deviations in frequency and sensitivity responses of the packaged devices were also observed in the case of etching using strong acid [3]. The investigations showed that the humidity affects the quality of ZnO layer and performance of device in case of non step coverage. However, it does not affect the capacitance as well as performance of device in case of proper step coverage of ZnO layer. The influence of temperature on ZnO layer was also studied. It was observed that the dielectric constant of ZnO layer changed with temperature. The corresponding dielectric loss tan δ was also increased. This variation of capacitance and the corresponding loss affects the performance of the device such as sensitivity and bandwidth.

References:

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