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Low stress ZnO thin films for smart MEMS device applications

Jitendra Singh
Central Electronics Engineering Research Institute, India

Role of oxygen partial pressure (RO_2) on structural, optical and mechanical properties of nano-ZnO films has been investigated. Highly c-axis oriented ZnO thin films in nanometer rage were deposited at room temperature by RF reactive magnetron sputtering. It was found that stress is compressive in nature and varies in -0.06×10^9 dyne/cm^2 to -2.27×10^9 dyne/cm^2 range, as a function of oxygen partial pressure. The stress measurement results are consistent and agreement with X-ray Diffraction results. The in-plane residual stress strongly depends on processing parameters and nearly stress free nano-films can be obtained using optimal process parameters. The stressed film shows blue shift in band gap with increase of oxygen partial pressure. The observed variations in mechanical, structural and optical properties are correlated with film stress. Low stress, room temperate deposited piezoelectric nano-ZnO films are highly desirable for NEMS devices. Further, stresses relaxed ZnO thin film based devices are highly reliable, reproducible and exhibit enhanced performance. Yield and device life time can be improved by controlling film stress. In-plane stress primarily produced in ZnO thin films due to conditions imposed by underlying substrate and deposition process. Large in-plane stress can develop in ZnO thin films due to intrinsic or thermal stress. As known, MEMS devices are constituted of mechanical structures and composed of metal, dielectric and functional layers. The ZnO processing temperature must be lower to avoid multilayer inter-diffusion. Sharp, clean and crack free interfaces are highly desirable in NEMS. When NEMS devices exposed to higher temperature, there are possibilities to develop cracks due to mismatch in thermal coefficient of expansion (TCE) of constituent layers. Therefore, there is a need of low process temperature and stress relaxed ZnO film deposition which is established in present investigation. Low stress ZnO films have various applications in functional MEMS devices.

jitendra@ceeri.res.in