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Deposition of ZrO_2 thin films using RF magnetron sputtering and characterization of their physical properties on different O_2 concentrations

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Thin films of ZrO_2 were deposited on Si(100) and Micro Cover glass substrates using RF magnetron sputtering technique. To study an influence of the sputtering parameters such as RF power magnitude, annealing temperature and different O_2 flux, etc. on the film structure and optical and electrical properties, a systematic study using XRD, AFM, FT-IR, I-V and C-V was mainly carried out in this study. Moreover, the as-grown thin films were characterized with FT-IR, RBS, SEM, and contact angle measurements to analyze their surface characteristics. XRD showed that a highly oriented cubic ZrO_2 thin film in the <111> direction was obtained after annealing at 800 ℃. On the other hand, tetragonal ZrO_2 thin film was deposited above 800 ℃ of annealing temperature. Below 800 ℃, moreover only amorphous ZrO_2 thin films with cubic phase were grown. SEM and ellipsometry showed the growth rate determined by variation of film thickness is increased with RF power magnitude. FT-IR data showed a strong vibration peak at 453 cm-1 due to Zr-O vibration. With increasing annealing temperature to 1200 ℃, however, another vibration peak was also arised at 1081 cm^{1}. This means that at higher annealing temperature, the surface oxygen will be diffused into the bulk, resulting in a SiO_2 layer formation in the interface region. To prove this phenomena more clearly, the same experiments of ZrO_2 thin film deposition were carried out under different oxygen plasma condition. The annealing temperature also affected the film micro hardness and those values were increased with increasing annealing temperature. From the I-V and C-V measurements, dielectric constant and leakage current density were also observed to be 5 and 1×10^{11} A/cm^2.