LOW TEMPERATURE PROCESSING OF SiO_2 THIN FILMS BY PECVD TECHNIQUE USING AN INDUCTIVELY-COUPLED HIGH-DENSITY RF PLASMA SOURCE

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An inductively coupled high-density rf plasma process was developed for the deposition of SiO_2 thin films for gate dielectric applications. High quality SiO_2 thin films were deposited at a processing temperature of 360 ^oC by high-density plasma enhanced chemical vapor deposition (HD-PECVD) process from a gas-phase combination of N_2O, N_2 and SiH_4. The SiO_2 thin film deposition process was optimized in terms of correlation among the deposition rate, etch rate, and optical properties as a function of system pressure, rf power, gas composition, and substrate temperature. The refractive index and chemical bonding of the SiO_2 thin films were determined by spectroscopic ellipsometry and Fourier transform infrared spectroscopy techniques. The combination of the FTIR spectroscopy and the ellipsometry data showed high sensitivity to the process variables and was able to provide information about the observed trend in the growth and optical properties of the SiO_2 thin films. The films deposited at the optimized processing conditions exhibited refractive index value close to thermal oxide indicating high density of the as-deposited films. The FTIR spectra of the films indicated stoichiometric bond formation with no detectable impurity related bonds at a deposition temperature of 360 ^oC.

The electrical properties of the SiO_2 thin films were measured on MOS capacitors. The effects of the film thickness and post-deposition annealing temperature on the electrical properties were also investigated. The MOS capacitors were fabricated by sputtering and patterning TiN on the top surface of the films deposited on *p*-type prime grade Si wafers. The leakage current density of the SiO_2 thin films was lower than 10^{-7} A/cm^2 even up to an applied electric field of 8 MV/cm while the physical breakdown field strength was greater than 10 MV/cm, indicating a highly dense and stoichiometric microstructure with low defect concentration. The Si/SiO_2 interfacial characteristics were determined from the high-frequency and quasi-static C-V measurements. The films exhibited good Si/SiO_2 interfacial characteristics with a low flat-band voltage of about –1.8 V. The fixed oxide charge density and the mid-gap interface trap concentration of the films were 2.8×10^{11} cm^{-2} and 8.6×10^{10} $cm^{-2}eV^{-1}$, respectively. The observed microstructural, electrical, and reliability properties of the present SiO_2 thin films show the effectiveness of the high density plasma process in low temperature processing of SiO_2 thin films with good bulk and interfacial characteristics.