Characterization of reactive RF-sputtered RuO2 as gate electrodes for high-k dielectrics

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Abstract

As silicon CMOS devices are scaled below 100 nm, advanced high-k gate dielectrics will be required to obtain oxide equivalent thickness $T_{ox-eq} < 1.0$nm. As $T_{ox-eq}$ decreases, boron doped poly-silicon depletion problem as well as leakage current from quantum mechanical tunneling becomes severe, making it necessary to consider alternative gate electrodes. The metallic oxides of transition metals may present a very attractive option in a variety of VLSI applications as it should be less reactive with the alternate high k materials being considered. Thin films of RuO$_2$, IrO$_2$ are attractive gate electrodes because of their compatible work functions, low resistivity and excellent thermal stability. RuO$_2$ thin films were deposited using RF magnetron sputtering system. The working pressures, sputtering gas ratios of O$_2$ to (Ar+O$_2$) and sputtering power were controlled from 10 to 20mTorr, 0 to 50% and 75 to 150W, respectively. Then post-annealing was done at 400°C to 800°C in N$_2$. Profilometry and X-ray reflectivity was used to measure the thickness of the films. AFM measurements give the information on morphology. X-ray diffraction patterns were measured to study grain structure and interface reactions. XPS was done to measure the surface chemical composition. Van Der Pauw method was used to measure the resistivities.