Electrical and Physical Characteristics of Ferroelectric and Dielectric Thin Films Synthesized by MOD Method

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Abstract

This thesis is presented as two sections. One section is concerned with the electrical and physical characteristics of ferroelectric films, SBT and BNT, deposited by chemical solution method. Another section is the electrical and physical characteristics of high dielectric constant materials prepared by the same way. The $Sr_{0.8}Bi_{2+x}Ta_2O_{9+\delta}$ (SBT) thin films are deposited on $Ir/SiO_2/Si$ substrate by using the metal-organic decomposition (MOD) technique. All the major peaks of the XRD pattern for $Sr_{0.8}Bi_{2+x}Ta_2O_{9+\delta}$ thin films correspond to SBT phase excepted x equal to 0. The excess 30% Bi of $Sr_{0.8}Bi_{2+x}Ta_2O_{9+\delta}$ thin films exhibit prefer oriented (115) phase, the microstructure, P-E hysteresis loops and leakage current are found to be dependent on the bismuth content. From above results, we find that $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ (SBT) is the optimum compositions.

The crystallization of the $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ (SBT) thin films annealed at various temperatures is investigated. The polarization (P) versus electric field (E) characteristics exhibits systematic variation from linear to nonlinear polarization with increasing annealed temperature. The

leakage current density and dielectric constant of $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ thin films also are strongly dependent on annealed temperature, which are determined by the grain size, mean surface roughness and inter diffusion on interfacial layer. Both of the leakage current density and dielectric constant increase with increasing annealed temperature.

The $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ (SBT) thin films is deposited on Pt/Ti/SiO_2/Si (MIM structure) and CeO_2/Si (MFIS structure) substrates annealed at 700 ℃. In order to prevent the generation of higher leakage current and diffusion between two layers, the STO ($SrTiO_3$) is also seeded on two substrates. The $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ (SBT) thin films with a STO seeded layer on MIM structure show preferred (115) orientation, good crystallinity and lower crystallization temperature than those without STO seeding layer. The SBT thin films with STO seeded layer on MFIS structure also appear prefer (115), (006) orientation and good crystallinity. The seeded layer of STO effectively resists the diffusion of Bi into Ir bottom electrode on MIM structure. The remanent polarization and leakage current density of $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ thin films with STO seeded layers are significantly improved. In MFIS structure, the $Sr_{0.8}Bi_{2.6}Ta_2O_{9+x}$ thin films with STO seeded layer are improved memory window and lead to lower leakage current at low voltage.

The $Bi_{3.25}Nd_{0.75}Ti_3O_{12}$ thin films are grown on $SrRuO_3$/$SrTiO_3$/Si substrates at 700°Cannealed temperature by metal-organic deposition can obtain higher remanent polarization. The remanent polarization (P_r) and coercive field (E_c) of the BNT ($Bi_{3.25}Nd_{0.75}Ti_3O_{12}$) thin film are 58 μC/$cm^2$ and 104 kV/cm, respectively. The memory window both of BNT and SBT thin films increases with increasing area ratios of MIS to MIM capacitor.

The next section, we investigate the physical and electrical characteristics of $SrTiO_3$-(x)SiO_2 ($SrTiSi_xO_{3\pm y}$) thin films varying x from 0 to 0.45. The 110 nm thicknesses of $SrTiSi_xO_{3\pm y}$ thin films have been prepared by chemical solution deposition (CSD) method at various annealed temperatures. Both of the leakage current density and dielectric constant of the thin films are obviously affected by crystallinity, annealed temperature and Si content. The Si content of $SrTiSi_xO_{3\pm y}$ thin film will depress the STO grain growth, produce lower dielectric constant and induce lower leakage current density. The dielectric constant of $SrTiSi_xO_{3\pm y}$ thin films increases with increasing annealed temperature and decreases with increasing Si content. The leakage current density of $SrTiSi_xO_{3\pm y}$ thin films decreases with increasing x value up to 0.25. The $SrTiSi_xO_{3\pm y}$ thin films with x equal to 0.25 have suitable dielectric constant and the lowest leakage current at 700°Cannealed temperature. The TDDB (Time dependent dielectric breakdown) curve of the $SrTiSi_xO_{3\pm y}$ films with x equal to 0.25 operated at an electric field of 0.6 MV/cm have lifetime over 10 years at 700°C and 800°C annealed temperature.