We report on the surface morphology and electrical characteristics of Al$_2$O$_3$/n-Si, TiO$_2$/n-Si, and Al$_2$O$_3$/n-GaN grown on sapphire, metal-oxide-semiconductor (MOS) capacitors. Al$_2$O$_3$ films were deposited on Si and GaN by atomic layer deposition (ALD) at temperatures ranging from 240-300°C. Electrical properties of all samples were investigated using capacitance-voltage (C-V), current-voltage (I-V) and conductance-frequency (G/ω-f) measurements. The oxide layer thickness of TiO$_2$ on Si was between 18-21 nm and that of Al$_2$O$_3$ on GaN was between 19-25 nm. Al$_2$O$_3$ layer on Si was thick. Thickness of Al$_2$O$_3$ and TiO$_2$ was measured by spectroscopic ellipsometry.

Surface morphology of the oxide layers was investigated with atomic force microscopy (AFM) and scanning electron microscopy (SEM). Structural properties of the MOS structures were confirmed by x-ray diffraction (XRD) and chemical composition was determined from x-ray photoelectron spectroscopy (XPS). In addition, the GaN crystalline structure was observed in XRD.

We demonstrate that the interface electrical quality of TiO$_2$/Si is superior compared to that of Al$_2$O$_3$/Si and Al$_2$O$_3$/GaN. Due to the presence of interface traps, a hysteresis loop was observed [1] during reverse voltage sweep in Al$_2$O$_3$/n-Si (Fig. 1) and Al$_2$O$_3$/n-GaN (Fig. 3). But hysteresis was not easily distinguishable in TiO$_2$/n-Si MOS structures (Fig. 2).

We investigated the effect of Al$_2$O$_3$ deposition temperature on electrical properties. The dielectric constant $k$ at 1 MHz, for Al$_2$O$_3$/GaN films deposited at 300°C, was ~8.6, which is close to the accepted value of ~9 for amorphous Al$_2$O$_3$ as reported in the literature [2]. Interface trap densities, $D_i$, on the order of $10^{12}$ eV$^{-1}$ cm$^{-2}$ were extracted from measurement at room temperature [3] by the conductance method. The presence of $D_i$ was also analyzed by evaluating the variation of the flatband voltage on high and low frequency of the C-V data.

Current-voltage measurement showed low leakage current density on the order of $10^{-8}$ A/cm$^2$ at zero voltage bias for TiO$_2$ on Si and that of $10^{-9}$ A/cm$^2$ at zero voltage bias for Al$_2$O$_3$ on Si and GaN. Finally, we demonstrate that Al$_2$O$_3$ and TiO$_2$ are excellent gate dielectrics for MOS field effect transistors.

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**REFERENCES**