ALUMINIUM OXIDE THIN FILMS GROWN BY LOW PRESSURE MOCVD USING ALUMINIUM ACETYLACETONE AND NITROUS OXIDE

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Aluminium oxide films are extensively used in various fields of science and technology, such as abrading coatings, antireflection coatings etc. Aluminium oxide is also being examined as alternates to SiO_2 as gate dielectric for next generation of ultra large-scale integration (ULSI) complementary metal oxide semiconductor (CMOS) devices, because of its higher dielectric constant (ε~9) than SiO_2 (ε~3.9) [1]. Aluminium oxide exhibits a number of crystallographic phases, such as α, γ, δ, κ, θ, and χ alumina [2]. Both the κ and α phases of alumina are usually prepared through chemical vapour deposition (CVD) techniques.

In this work, thin films of aluminium oxide have been grown on various substrates, such as Si, TiN/WC, fused quartz etc, in the temperature range of 450-1100°C by low pressure metalorganic chemical vapour deposition (MOCVD) using aluminium acetylacetonate as precursor. Films were grown in inert and oxidizing ambient. X-ray diffraction and electron diffraction study shows that the films are polycrystalline in nature. Scanning electron microscopy study reveals that the films grown on Si substrates at lower temperature (~ 600°C) has a very smooth mirror-like reflecting surface whereas films grown at higher temperatures are grainy. Films grown at TiN/WC at lower temperature has spherulitic features, which is due to melting of precursor molecule or its cluster [3].

To examine chemical nature of constituents present in the film X-ray photoelectron spectroscopy (XPS) was carried out. Figure 1 shows the full survey XPS spectra of aluminium oxide film grown on silicon under 60/30sccm of N_2O/Ar flow. Survey of XPS spectra reveals that the film comprises Al, O, C, and Ag. Ag was used as internal XPS standard. XPS depth analysis of constituents reveals that carbon is present throughout the depth of the film and it is graphitic in nature, which was subsequently confirmed by secondary ion mass spectroscopy (SIMS) depth profile analysis. Core level XPS spectra of Al(2p) (figure 2) reveals that the binding energy of aluminium is 74.5eV, which corresponds to the Al^{3+} state. Symmetric nature of core level XPS spectra of Al(2p) clearly reveals that no other sub oxides of Al are present in the film.

Room temperature high frequency capacitance–voltage (C-V) characterization was carried out on $Al/Al_2O_3/Si$ MIS structure. Figure 3 shows the C-V characteristic of aluminium oxide film grown at 600°C under 60/30sccm of N_2O/Ar flow. This curve reveals that there is a large stretch out in C-V characteristic. Using C-V curve the fixed charge calculation was done which is ~10^{11}qC/cm^2 and dielectric constant is of the order of 6. In order to understand the unusual C-V characteristics behaviour, microstructure and composition of the films should be taken into account. Presence of graphitic carbon and hydrogen (as confirmed by FTIR) in the film leads to the generation of extra charge trap centers causing a large stretch out in C-V curve.

REFERENCES

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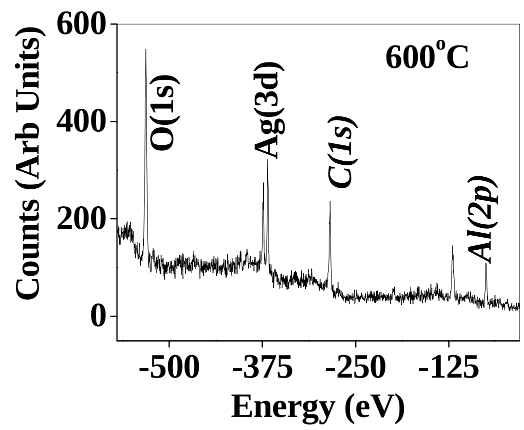

Figure 1. Full XPS spectra of aluminium oxide film grown on Si at 600°C under 60/30sccm of N_2O/Ar flow.

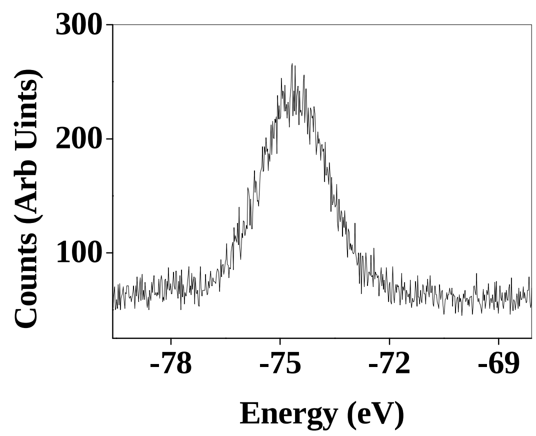

Figure 2. Core level XPS spectra of Al(2p) of aluminium oxide film grown at 600°C under 60/30sccm N_2O/Ar flow.

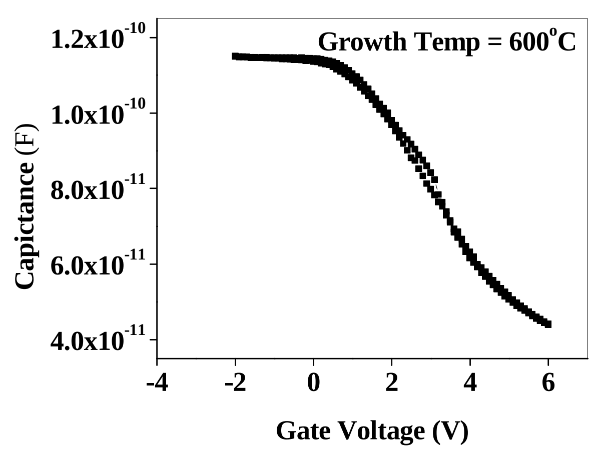

Figure 3. C-V characteristics of aluminium oxide film grown at 600°C. (Capacitance area = 7.85x 10^{-3} cm^2).