CHARACTERIZATION OF A POTENTIAL GATE DIELECTRIC: MOCVD-GROWN ERBIUM OXIDE ON SILICON

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The continuing scaling down of complementary metal oxide semiconductor (CMOS) -based devices leads to the serious problem of gate leakage (tunneling) current. Many materials, such as Al_2O_3, HfO_2, Ta_2O_5 etc. are currently under consideration as the potential alternative gate dielectric for next generations of CMOS-based devices [1,2]. In this search, Er_2O_3, erbium oxide, offers an attractive alternative to SiO_2 because its dielectric constant (ε~14) is four times that of SiO_2 (ε~ 3.9), and its large bandgap of ~5.6eV [3,4].

In this paper, we report the structural and electrical characterization of erbium oxide films grown on n-type Si(100) by low-pressure metalorganic chemical vapour deposition (MOCVD) using a β-diketonate complex of erbium. Structural and morphological studies were carried out using various techniques such as X-ray diffractometer (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and atomic force microscopy (AFM), which indicate that films grown at lower temperatures (~500°C) are poorly crystalline, whereas films grown above 500°C are polycrystalline with texture. Morphological study reveals that films grown at lower temperature are smooth and mirror-like, whereas films grown at higher temperature are somewhat grainy. Chemical characterization of the films was carried out by Fourier transform infrared (FTIR) spectroscopy and Auger electron spectroscopy (AES). Figure 1 shows the AES depth profile of Er_2O_3 film grown at 600°C, which reveals that the film is carbon-free.

Room temperature high frequency (1MHz) C-V and I-V characterization of the film was carried out on $Al/Er_2O_3/Si$ MIS structures at room temperature. The dielectric constant, flat band voltage, and fixed charge density were extracted from the C-V data (figure 2). For the device made with the film as grown at 525°C, the flat band voltage V_{fb} ~ 3.6 V, and the fixed charge (Q_f) = -3.93x10^{11} qC/cm^2. After annealing in O_2 at 600°C for 20 min, V_{fb} ~ 0.35 V and Q_f = –1.93x10^{10} qC/cm^2. I_g-V_g characteristic for 525°C grown film is shown in figure 3. Films grown at higher temperatures are more leaky than those grown at lower temperatures (~500°C). The effect of rapid thermal annealing on the dielectric and transport properties of erbium oxide films will be presented, and contrasted with those of “normal” annealing.

REFERENCES

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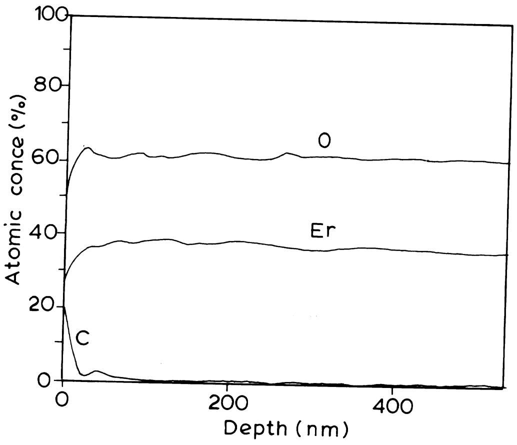

Figure 1. AES depth profile of Er_2O_3 film grown at 600°C.

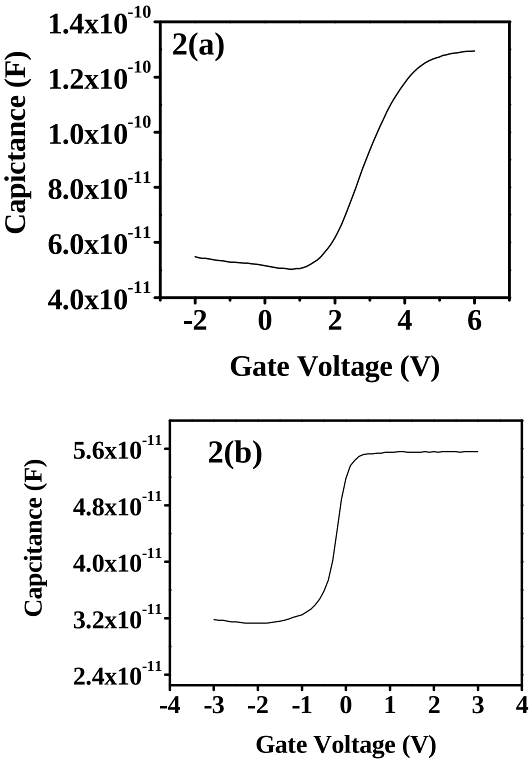

Figure 2. High frequency C-V characteristics on (a) as grown 525°C and (b) post annealed at 600°C in O_2 ambient. (Capacitance area = 7.85x 10^{-3} cm^2).

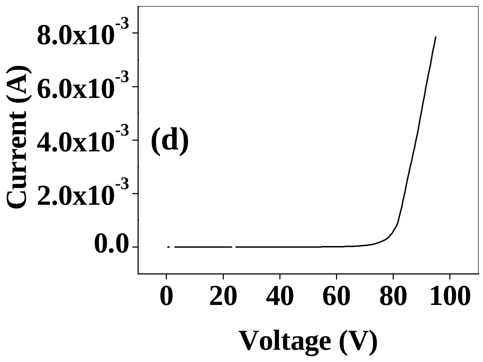

Figure 3. I_g-V_g characteristics of MIS capacitor. (Thickness of erbium oxide film = 1μm).