STRONGLY ORIENTED THIN FILMS OF Er_2O_3 GROWN ON FUSED QUARTZ BY LOW-PRESSURE MOCVD

M. P. Singh, K. Shalini, and S.A. Shivashankar
Materials Research Centre,
Indian Institute of Science, Bangalore-560012, India

Thin films of erbium oxide, Er_2O_3, exhibit interesting physical properties, such as good transparency from ultraviolet to infrared region, high refractive index, good dielectric and insulating properties because of a relatively high dielectric constant, low dielectric losses, as well as high dielectric breakdown field strength [1]. Erbium 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~12-14) than SiO_2 (ε~3.9) [2,3]. Various techniques such as thermal evaporation and anodization [2,3] have been employed for the preparation of erbium oxide thin films. Films prepared by the above techniques are either amorphous in nature or polycrystalline without any texture.

In the present work, thin films of erbium oxide have been deposited on fused quartz substrates in the temperature range of 450-1000°C by low-pressure metal organic chemical vapour deposition (MOCVD) using tris(2,4-pentadionato)(1,10-phenanthroline)erbium(III) as precursor. The films were characterized by various techniques to study their crystallinity, morphology, and the optical properties. While the films grown below 550°C are poorly crystalline, those grown above 550°C display a strong (111) texture (Figure 1), which is interpreted in terms of minimization of surface energy. Electron diffraction study of Er_2O_3 film grown at 700°C also shows the texture, thereby confirming the XRD findings.

The study of morphology of the films by optical and scanning electron microscopy shows that the films grown at lower temperature (~ 500°C) are very smooth , whereas films grown at higher temperatures comprise small, nearly spherical grains. TEM study reveals that the films are essentially pore-free and comprises nano-sized (~ 20-50 nm) grains.

Fourier transforms infrared (FTIR) spectroscopy and UV–visible characterization was carried out to examine the optical properties of Er_2O_3 films. Figure 2 shows the FTIR spectra of the films grown at various temperatures. The FTIR spectrum has been recorded to find out the presence of hetero-atoms (such as carbon) in the films and their chemical nature. The spectra show that there is a very small amount of O-H present in the film. This is due to the absorbance of the moisture from the atmosphere. There are two distinct bands at ~670 cm^{-1} and ~415 cm^{-1}, which are due to the Er-O-Er and Er-O, respectively. The FTIR spectra reveal further that there is no carbonate formation in the films, indicating that the films are carbon-free. The optical transmittance of the Er_2O_3 film grown at 700°C is shown in Figure 3. The thickness of the film is 600 nm, while its roughness is ~12 nm, as measured by stylus profilometer. The transmittance of the film in UV-visible range is as high as 90%, which clearly indicates that the film is heteroatom-free, substantiating the FTIR data. A sharp absorption edge observed at ~ 225 nm, indicated the band gap of ~5.5 eV.

REFERENCES

1. T. Wiktorczyk, *Opt. Appl.*, **31**, 5 (2001).
2. H. Ono and T. Katsumata, *Appl. Phys. Lett.*, **78**, 1832 (2001).
3. V. Mikhelashvili, G. Eisentsein, and F. Edelmann, *J. Appl. Phys.*, **90**, 5447 (2001).

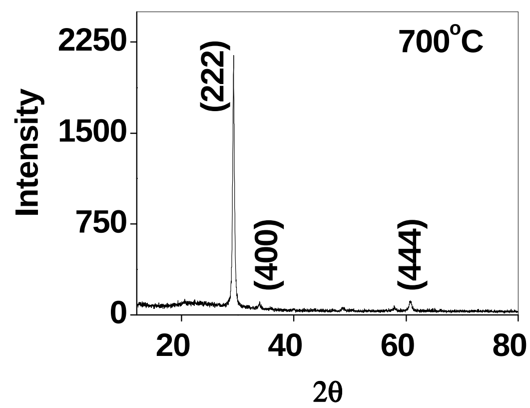

Figure 1. XRD pattern of thin film of erbium oxide grown at 700°C.

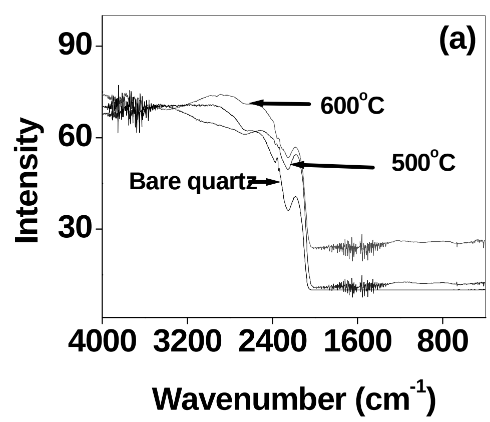

Figure 2. FTIR spectra of thin films of erbium oxide grown at various temperatures.

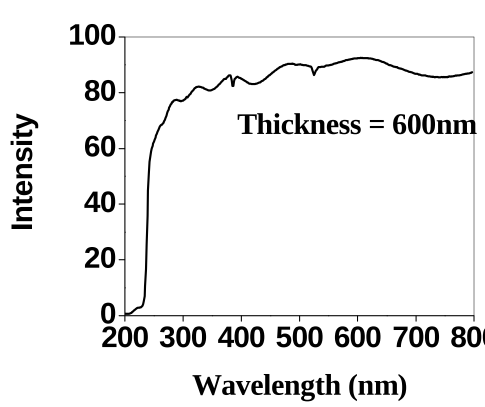

Figure 3. Transmittance UV-Visible spectrum of thin film of erbium oxide grown at 700°C.