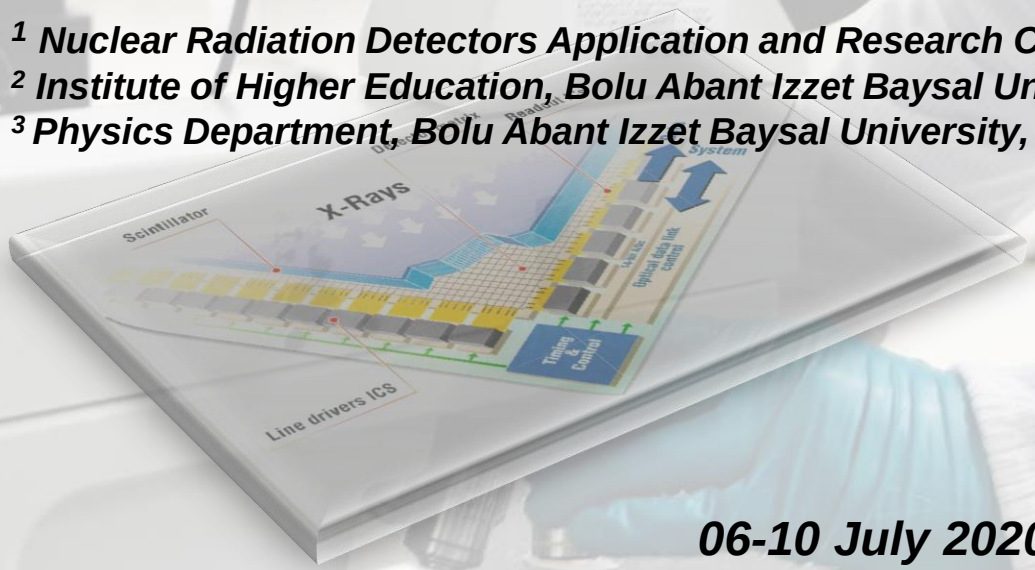
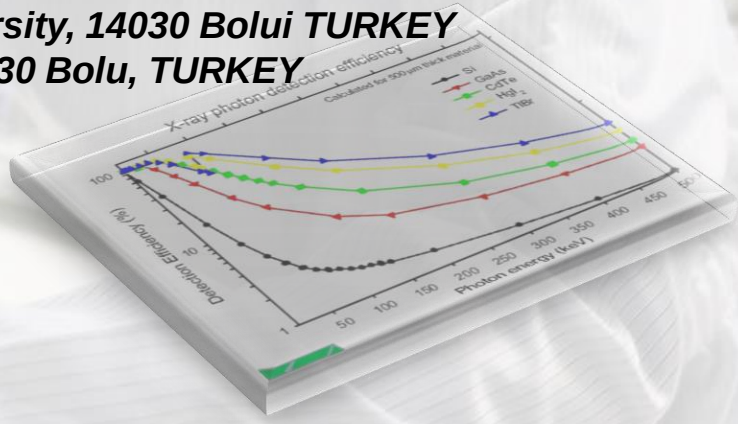
Effects of annealing temperature on the crystallographic, morphological and electrical characteristics of E-Beam deposited Al/Eu_2O_3/n-Si (MOS) capacitors

Ozan YILMAZ[1,2] and Ercan YILMAZ[1,3,*]

[1] Nuclear Radiation Detectors Application and Research Center, BAIBU, 14030 Bolu, TURKEY
[2] Institute of Higher Education, Bolu Abant Izzet Baysal University, 14030 Bolui TURKEY
[3] Physics Department, Bolu Abant Izzet Baysal University, 14030 Bolu, TURKEY





06-10 July 2020, RAP 2020, Thessaloniki, GREECE

Content Outline

- *Introduction*
- *Experimental Details*
- *XRD Analysis Results*
- *FTIR Analysis Results*
- *Electrical Characteristics Results*
- *Conclusion*

Introduction

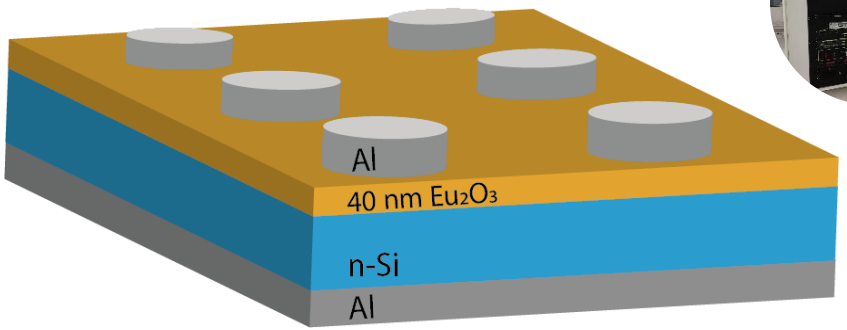
- Rare earth oxides (REO's) play an important role in semiconductor technology.
- Rare Earth Oxides (REOs) gained more attention for the improvement of the MOS devices.
- Europium oxide (Eu2O3) is one of the REO and it has been used in many applications such as optoelectronics, telecommunications, microelectronics and optical devices.(Kumar et al., 2015)
- Eu_2O_3;
  - ✓ high dielectric constant (k =14) (Kumar et al., 2015),
  - ✓ large energy band gap (4.4 eV),(Kumar et al., 2016; Petit et al., 2005; Singh & Shivashankar, 2005).
  - ✓ high chemical durability and thermal stability (Loureno et al., 2011).

Experimental Details

500 µm thickness, n-type (100) silicon substrate with a resistivity of 2-4 Ω cm

The standard Radio Corporation America (RCA) cleaning procedure

Eu_2O_3 thin films with thickness of 40 nm were deposited at 150 °C substrate temperature by using electron beam (e-Beam) evaporation.



Samples annealed at different temperatures such as 300 °C, 500 °C, 700 °C, 900°C for 40 min at N_2 ambient.

To Form Aluminium front electrodes using a shadow mask having circular dots of 1.5 mm diameter and to deposit Aluminium onto the whole back surface of the wafer by DC sputter.

- Types of chemical bonding in Eu_2O_3 were determined by a Perkin Elmer Spectrum Two FTIR-ATR spectrophotometer.

- Crystallinity of Eu_2O_3 was analyzed by a Rigaku Multifex difractometer employing CuKα radiation.

- The capacitance–voltage (C–V) and conductance–voltage (G/ω–V) measurements for fabricated Al/Eu_2O_3/n-Si (MOS) capacitor were performed at 1MHz at room temperature.

XRD Results

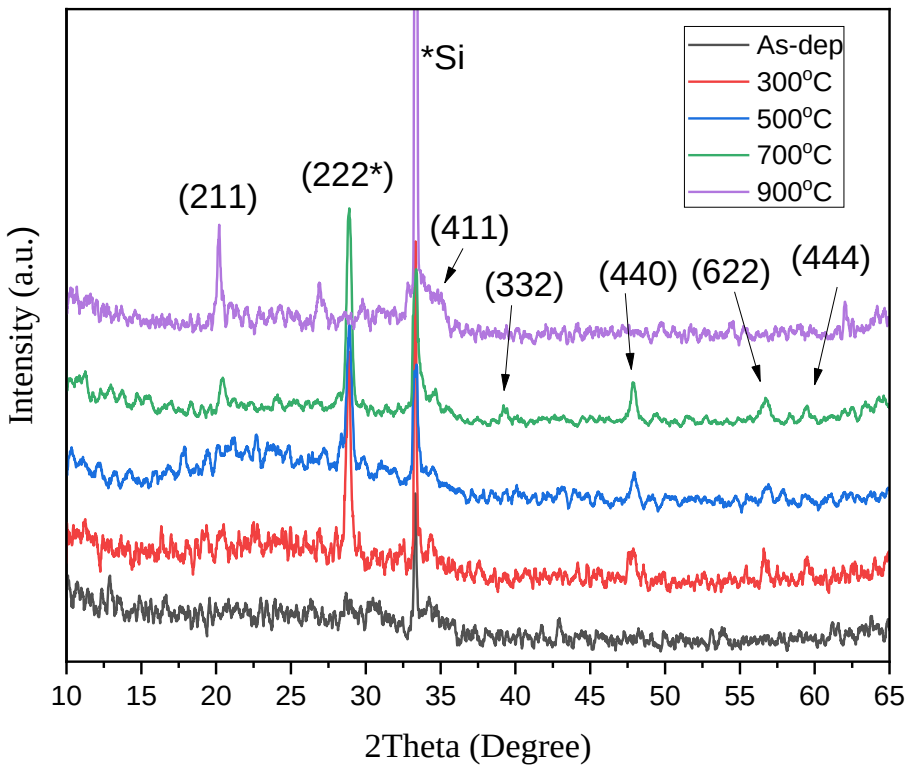


Figure 1: The XRD pattern of the Eu_2O_3/Si structure as- -deposited and annealed at 300 °C, 500 °C, 700 °C, 900 °C.

- The diffraction patterns of the annealed thin films can be indexed to the *cubic* phase, which is consistent with the values in the standard card (JSPDS no. 34-0392, quality «*», a value 10.86 nm).
- The values of grain size and crystallinity of the films increase with the increasing annealing temperatures, except 900°C annealed sample

Table 1: Grain size (nm) and Crystallinity (%) of deposited Eu_2O_3/Si depend on annealing.

Annealing Temp.	Grain Size (nm)	Crystalinity (%)
300°C	23.69	15.70
500°C	24.28	15.81
700°C	26.45	29.39
900°C	12.15	18.01

FTIR-ATR Results

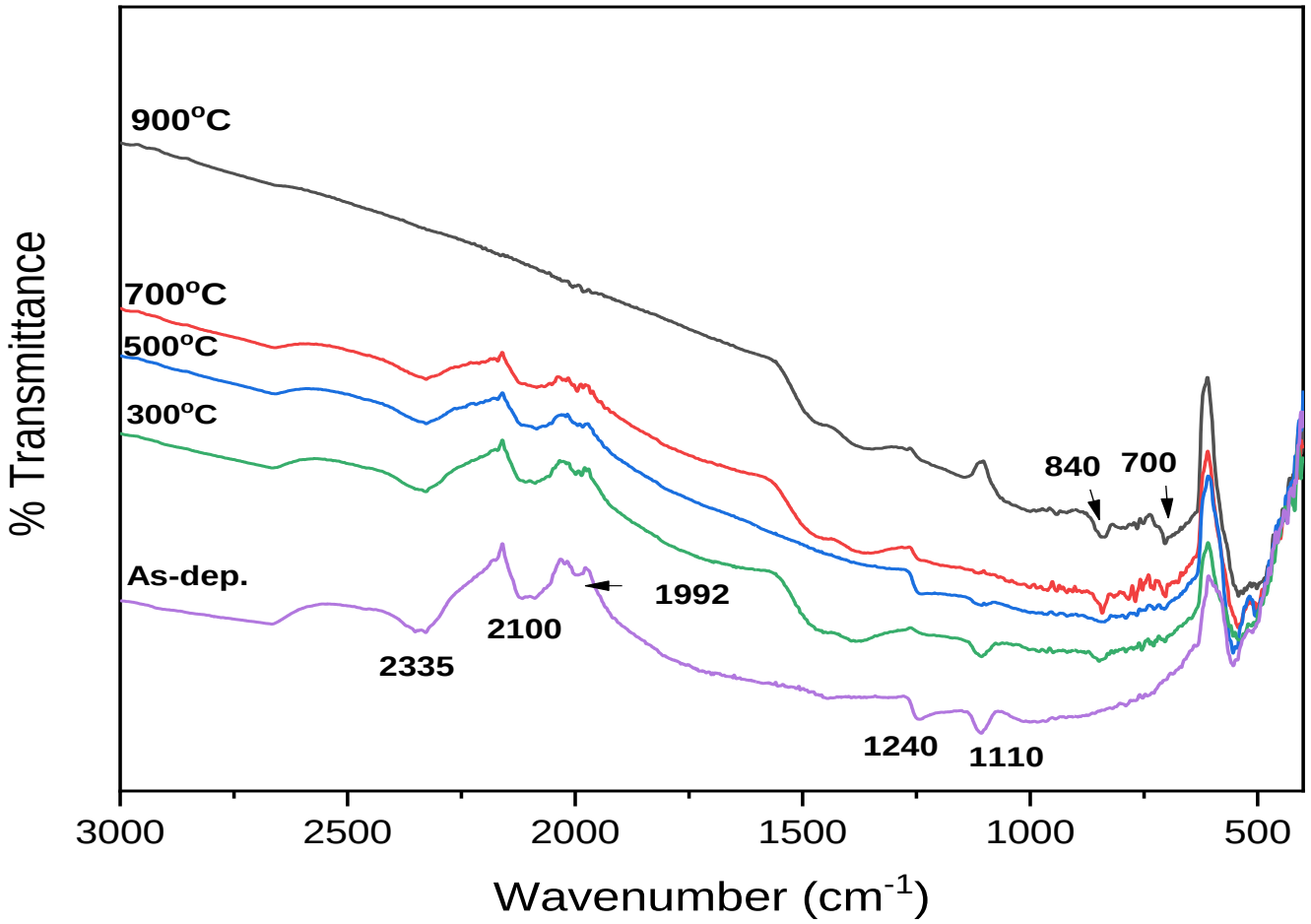
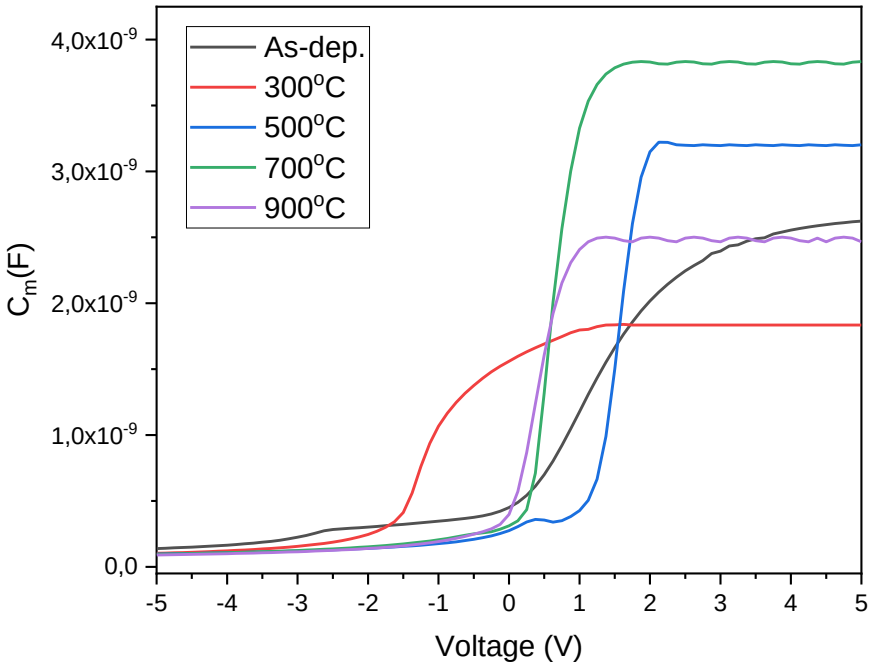


Figure 2: FTIR spectra of Eu_2O_3 /Si thin films at different annealing temperatures..

Electrical Characteristics Results



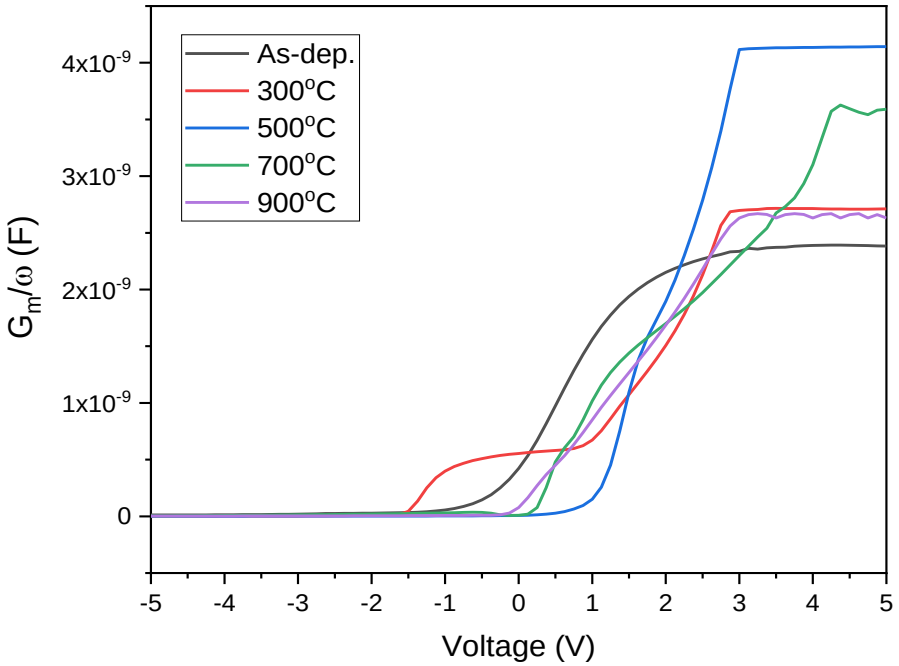


Figure 3: The electrical C-V and G/ω-V characteristics of Al/Eu2O3/Si/Al MOS capacitors.

Conclusion

- In this study, Eu_2O_3 MOS capacitors have been fabricated by using the Electron Beam Evaporation (E-Beam) technique and the effects of different annealing temperatures on them have been investigated.
- The crystallinity of Eu2O3 thin film is sensitive to the annealing, while the grain size of films slightly increases with annealing temperature increase.

- The result of ATR-FTIR measurements shows that the Eu-O bond has been found on thin film structures at 840 cm^{-1}, 700 cm^{-1} wavenumbers.

- The graphs of The C-V and G/w-V analyses show an increasing trend with the increasing annealing temperature.

- The results show that Eu_2O_3 rare earth materials can be a good candidate for microelectronic applications.

Acknowledgements:
This work is supported by the Presidency of Turkey, Presidency of Strategy and Budget under Contract Number: 2016K12-2834.

References:

- Dakhel, A. A. (2004). Characteristics of deposited Eu2O3 film as a thick gate dielectric for silicon. EPJ Applied Physics. https://doi.org/10.1051/epjap:2004171.
- Kumar, S., Prakash, R., Choudhary, R. J., & Phase, D. M. (2015). Structural, XPS and magnetic studies of pulsed laser deposited Fe doped Eu2O3 thin film. Materials Research Bulletin. https://doi.org/10.1016/j.materresbull.2015.05.007.
- Kumar, S., Prakash, R., & Singh, V. (2016). Synthesis, Characterization, and Applications of Europium Oxide: A Review. Reviews in Advanced Sciences and Engineering. https://doi.org/10.1166/rase.2015.1102.
- Loureno, S. A., Dantas, N. O., Serqueira, E. O., Ayta, W. E. F., Andrade, A. A., Filadelpho, M. C., Sampaio, J. A., Bell, M. J. V., & Pereira-Da-Silva, M. A. (2011). Eu3+ photoluminescence enhancement due to thermal energy transfer in Eu2O3-doped SiO2B2O 3PbO2 glasses system. Journal of Luminescence, 131(5), 850–855. https://doi.org/10.1016/j.jlumin.2010.11.028.
- Petit, L., Svane, A., Szotek, Z., & Temmerman, W. M. (2005). First-principles study of rare-earth oxides. Physical Review B - Condensed Matter and Materials Physics, 72(20), 1–9. https://doi.org/10.1103/PhysRevB.72.205118.
- Singh, M. P., & Shivashankar, S. A. (2005). Structural and optical properties of polycrystalline thin films of rare earth oxides grown on fused quartz by low pressure MOCVD. Journal of Crystal Growth, 276(1–2), 148–157. https://doi.org/10.1016/j.jcrysgro.2004.11.325

Thanks for Your Attention