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Rapid thermal annealing induced recrystallization led modification in structural and optical properties of Cu implanted $MgTiO_3$ thin films

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INTRODUCTION & AIM

- Investigation of structural, morphological, and optical properties of post-annealed Cu implanted $MgTiO_3$ (MTO) thin films has been carried out.
- Rapid thermal annealing (RTA) to alleviate the defects introduced during ion implantation.
- Crystallinity of films deteriorates drastically upon implantation, while post annealing leads to the recrystallization of samples.
- Implanted sample exhibits slightly higher transmittance than the pristine film, which gets reduced upon RTA.
- Bandgap of the pristine film is 4.17 eV.
- Implantation results in the shrinkage of bandgap to 3.90 eV, while post-annealing treatment slightly raises the bandgap of the films, which is an evidence of defects annihilation in the films upon post-annealing treatment.
- MTO thin film exhibits a broad PL emission band extending from near UV to visible region.
- Quenching in the luminescence is observed upon implantation.
- Post annealing at higher temperature of 800°C leads to a substantial increase in emission intensity.
- Similarly, time-resolved PL indicates a reduction in average decay lifetime of implanted films as compared to the pristine sample, while it is observed to vary with post-annealing treatment.
- A comprehensive study of recrystallization behavior of RTA treatment of implanted MTO thin films, from structural and optical aspects, was carried out in the present work.

METHOD

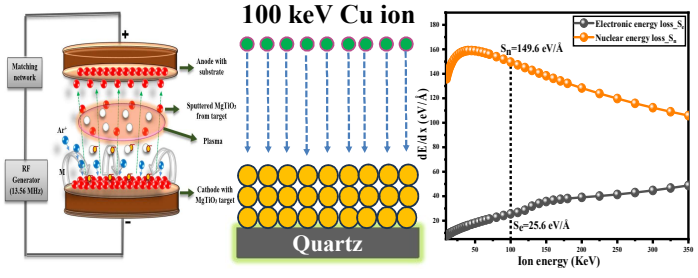

Figure 1: Schematic representation of RF Sputtering, Cu ion implantation, & energy loss variation into MTO matrix

Experimental Method:

- $MgTiO_3$ thin films were deposited using RF magnetron sputtering.
- As-deposited films were annealed at 750°C for crystallization.
- The films then implanted at 3×10^{15} ion/cm^2.
- Afterward the films were post annealed at three different temperatures 600, 700, & 800°C using Rapid-thermal-annealing.
- Rapid-thermal-annealing (RTA) leads to re-crystallization of films.
- Parameters of RTA:
  - Dwell time: 1 minutes
  - Ramp rate: 20°C/sec

RESULTS & DISCUSSION

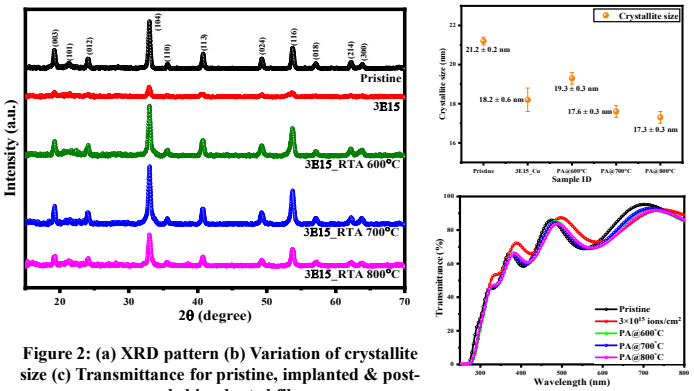

Figure 2: (a) XRD pattern (b) Variation of crystallite size (c) Transmittance for pristine, implanted & post-annealed implanted films.

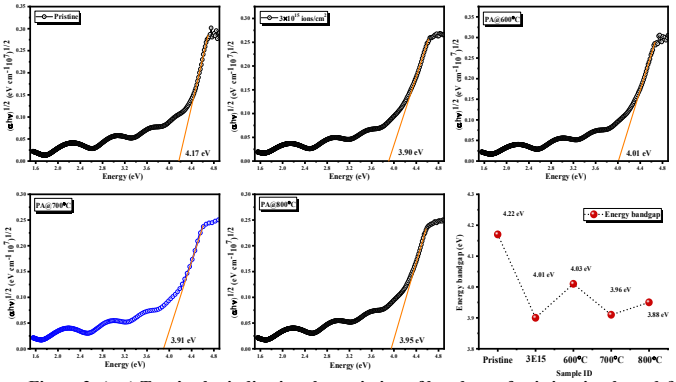

Figure 2: (a-e) Tauc's plot indicating the variation of bandgap of pristine, implanted & post-annealed implanted films.

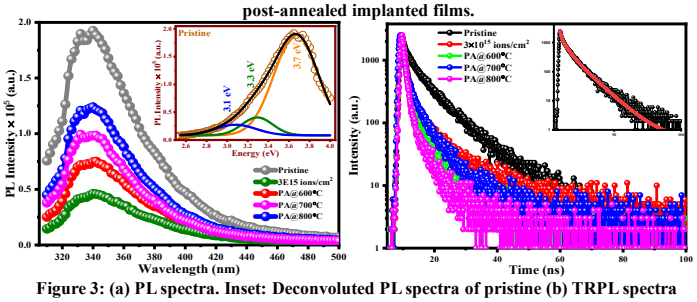

Figure 3: (a) PL spectra. Inset: Deconvoluted PL spectra of pristine (b) TRPL spectra of pristine, implanted & post-annealed implanted films. Inset:

CONCLUSION

A comprehensive study of recrystallization behavior of RTA treatment of implanted MTO thin films, from structural and optical aspects, was carried out in the present work. MTO exhibits rhombohedral crystal structure having bandgap lies in UV-region. MTO also show excellent luminescence in Near UV & Visible region with an average decay lifetime in 10s of nanoseconds. The observed results indicates the applicability of MTO in UV LEDs & optical applications.

FUTURE WORK / REFERENCES

(a) X. C. Liu et. al., J Mater Sci: Mater Electron 20, 323 (2009)
(b) K. Das et. al., J. Phys. Chem. C 113, 14783 (2009);
(c) D. Negi et. al., Journal of Luminescence 249, 119051 (2022);
(d) E. A. V. Ferri et. al., Journal of Physical Chemistry C 116, 15557 (2012)
(e) J. Xu et. al., Journal of applied physics 107, 053910 (2010)