Improvement of structural and electrical properties of RF sputtered CCTO thin films by post-deposition annealing

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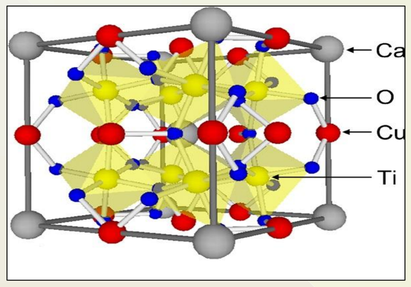
Abstract

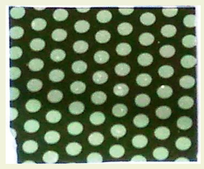
Calcium copper titanate (CCTO) sputtering target was fabricated by adopting solid state route. CCTO thin films were deposited on p-Si (100) substrates by RF magnetron sputtering technique at room temperature with RF power and deposition pressure of 105 W and 5 × 10^{-3} mbar, respectively. Post deposition annealing was carried out for the sputtered samples at different temperature ranging from 650 °C to 950 °C in air atmosphere. From X-ray diffraction, evolution of CCTO crystalline peaks was observed for thin film annealed at 950 °C. The surface morphology of the annealed thin film was found to be modulated with annealing temperature. Uniform distribution of microstructures was observed for the films annealed at higher temperature. Electrical properties of the annealed thin films were studied by fabricating Al/CCTO/Si MOS structures. The interface trap density (D_{it}) was calculated as 7.9 × 10^{10} $eV^{-1}cm^{-2}$ for the films annealed at 950 °C. Non-linear current-voltage characteristics have been observed for all the samples.

Introduction

- Distorted Cubic Perovskite Structure
- Im3 Space Group
- Lattice Parameter 7.39 Å
- Bulk Dielectric Constant 9,200 at 1MHz.
- Negligible Temperature dependence on k value (RT to 300 °C)
- Applications in capacitors, sensors, varistors, memory devices.



Unit cell of CCTO



Al/CCTO/Si MOS Structure

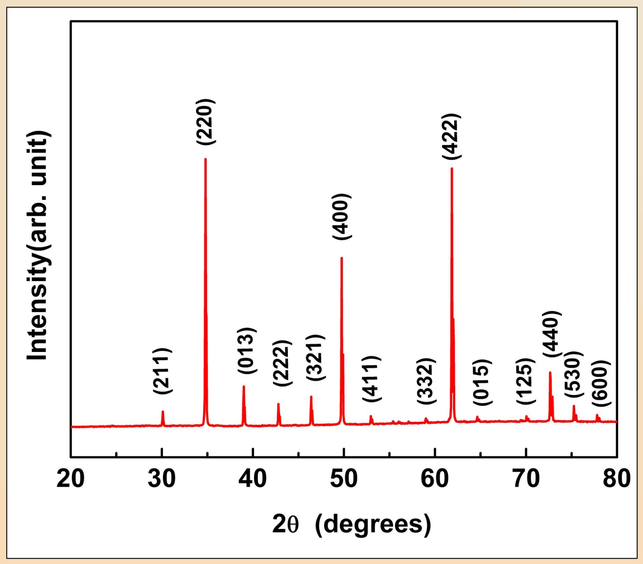
Experimental

CCTO sputtering target synthesized by Solid state route → 100nm CCTO thin film deposited on p-Si (100) substrate → Annealing temperature varied from 650 °C to 950 °C → MOS structures fabrication for measurement

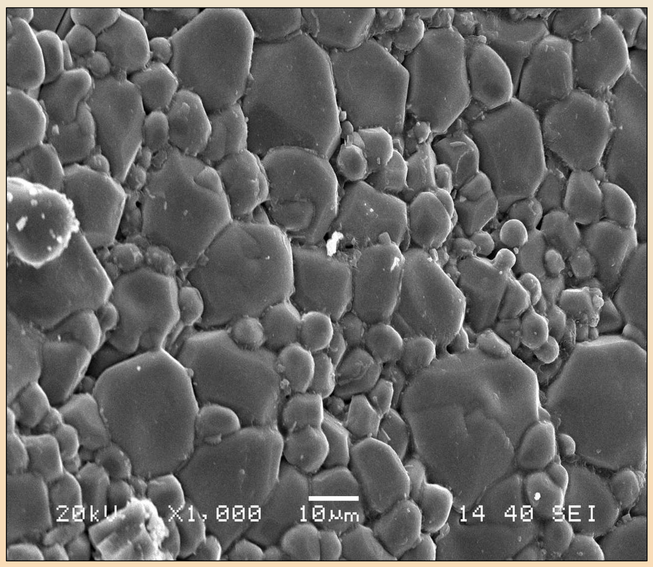
Deposition Parameters

- Sputtering Power - 105W
- Sputtering Pressure 5 × 10^{-3} mbar
- Room temperature deposition

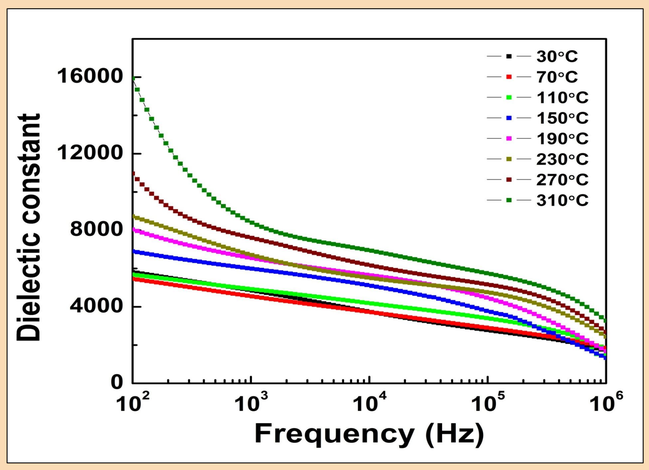
Result and Discussions



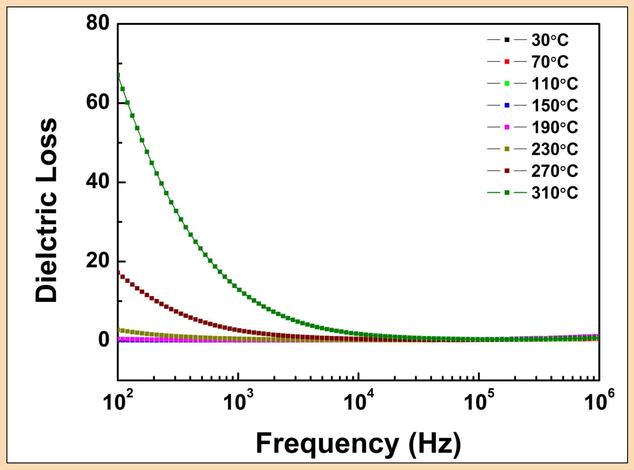
XRD patterns of the CCTO target



SEM image of CCTO target

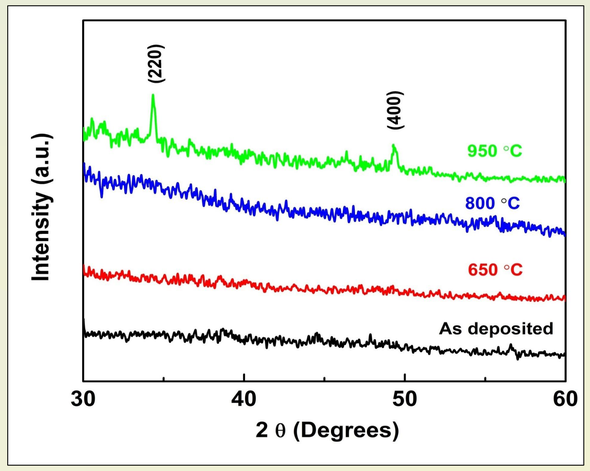


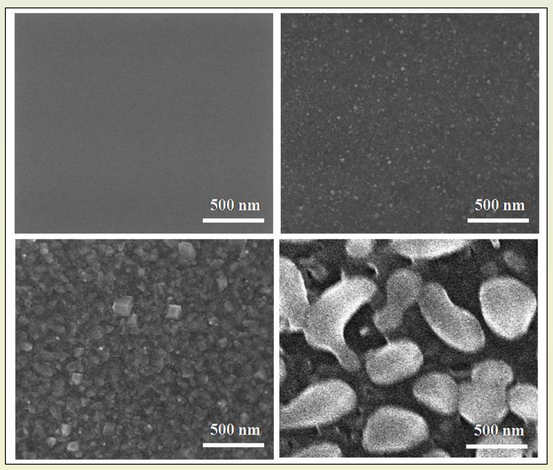
Frequency dependence of dielectric constant of CCTO pellet at different temperature



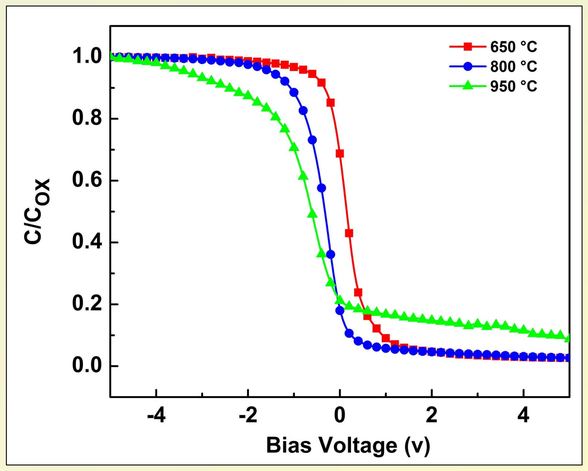
Frequency dependence of dielectric loss of CCTO pellet at different temperature

CCTO thin film characterizations

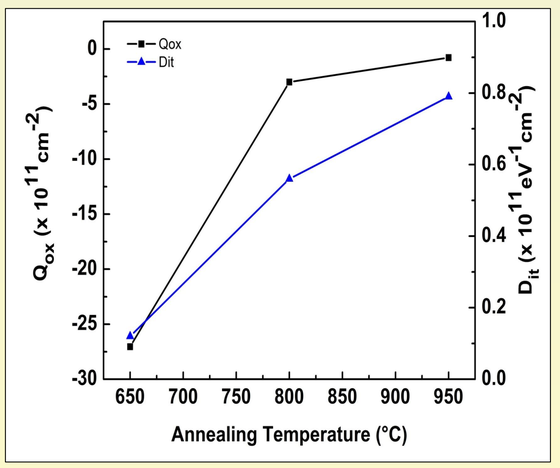




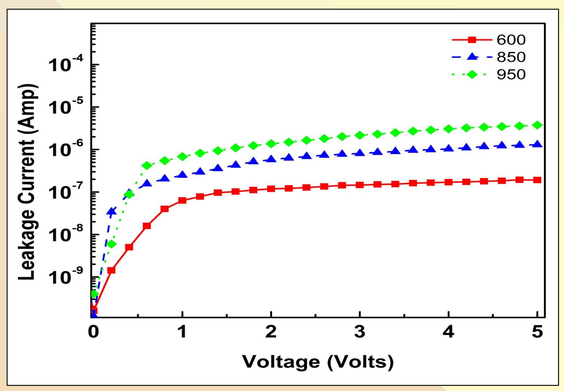
FESEM images and XRD pattern of CCTO thin films (a) As deposited, annealed at temperatures (b) 650 °C, (b) 800 °C, (c) 950 °C,



Normalized High frequency CV curves of Al/CCTO/Si MOS structure



Variation of oxide and interface charge densities of CCTO films different temperature



Current - voltage characteristics of CCTO films.

- CCTO phase formation was observed at 950 C
- Films annealed at lower temperature were found to be amorphous with no evolution of grains
- Oxide charge density and interface trap density increased with increase in annealing temperature

Conclusion

- ✓ CCTO sputtering target have been synthesized by solid state route. Thin film deposited by RF sputtering technique. With RF power 105W, deposition pressure 5 × 10^{-3} mbar .
- ✓ Thin films morphology is strongly modulated by annealing temperature.
- ✓ Film annealed at 950 ° C have shown better crystallinity

Acknowledgement

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References

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