Material, optical and electrical characterization of DC sputtered CuO by tuning oxygen concentration

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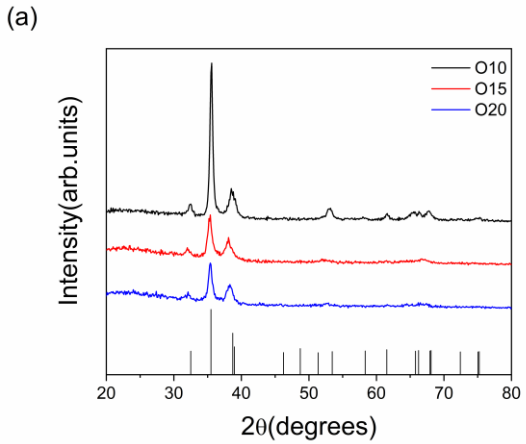
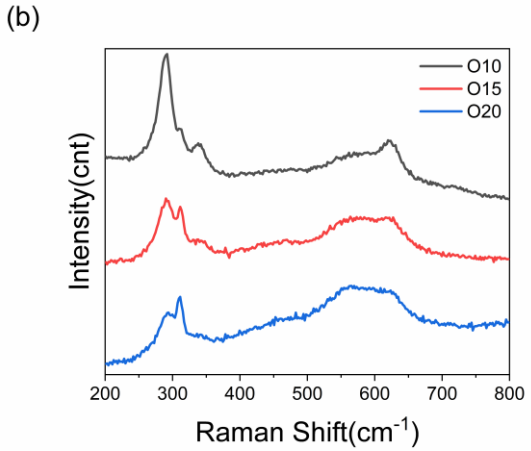
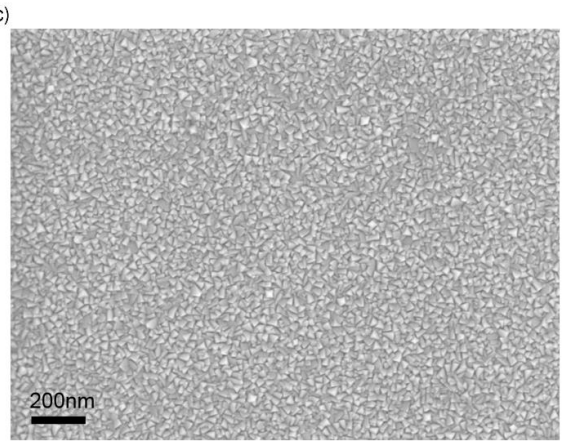
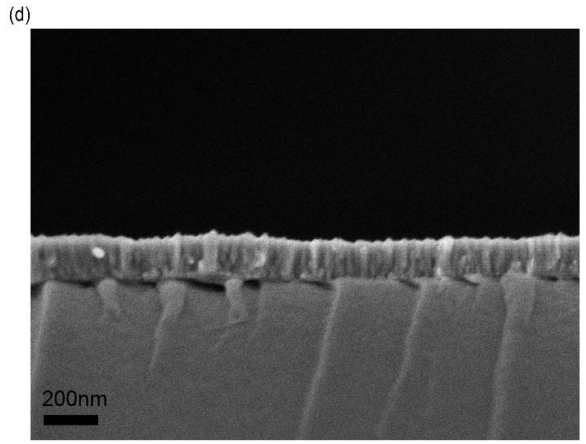
02 Material Characterization [1]

Sample	Target	O_2 (SCCM)	Ar (SCCM)	Power(W)	I(mA)	V(V)	Deposition Time	Temperature(˚C)	Base pressure (Torr)	Sputtering pressure (mTorr)	Thickness (nm)
O10	Cu	10	20	50	95	515	30min	Room	1.40E-07	5	160
O15	Cu	15	15	50	105	470	30min	Room	2.00E-07	5	65
O20	Cu	20	10	50	115	427	45min	Room	2.00E-07	5	66



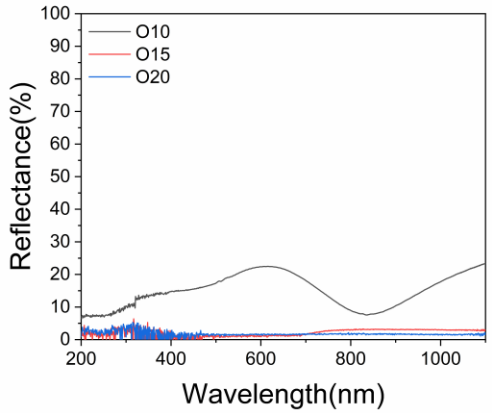




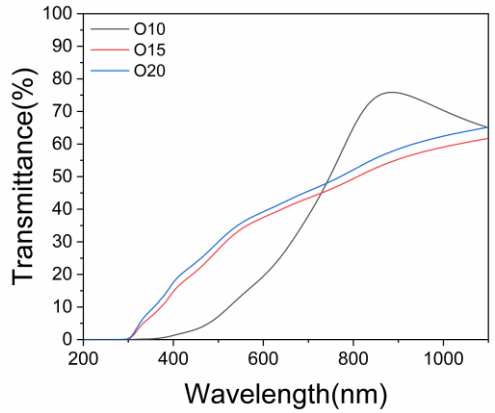


- Fig(a): XRD patterns exhibit tenorite CuO (JCPDS-45-0937)
- Fig(b): Raman peaks at 291, 343 and 623cm^{-1}
- Fig(c) and Fig (d): SEM of O10 Sample shows a triangular grain structure and a grain size around 20nm

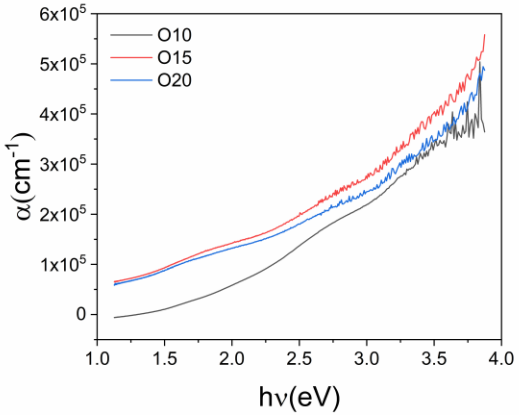
02 Optical Characterization



Reflectance spectra of CuO thin films

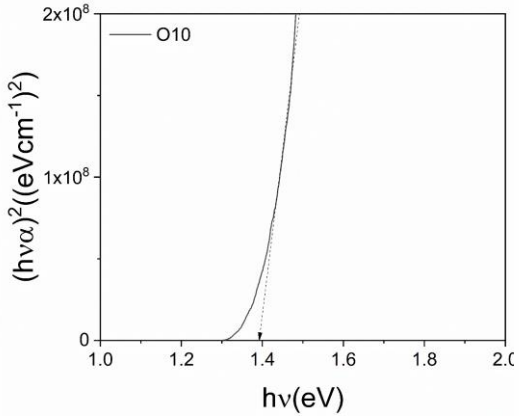


Transmittance spectra of CuO thin films

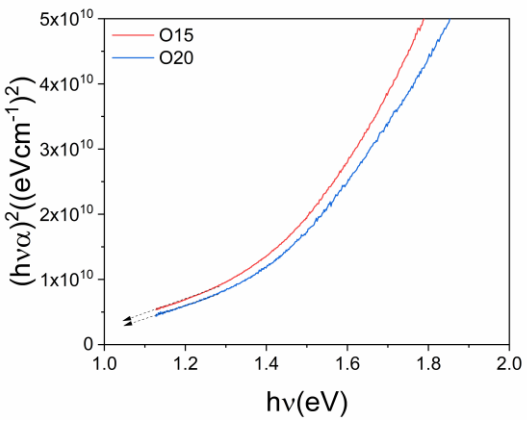


Absorption Coefficient spectra of CuO thin films

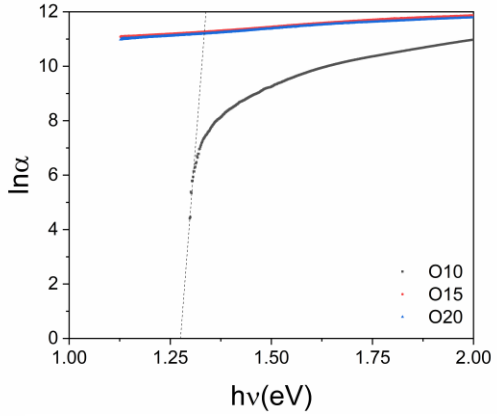
- Higher Absorption Coefficient for samples sputtered at higher O_2
- Bandgap decreases with increasing O_2
- Unpredictable Urbach energy for O15 and O20 Samples



Tauc plots of O10 sample



Tauc plots of O15, O20 samples



Urbach tails plots of CuO thin films

- Key parameters for O10 Sample:
  - R<25%
  - Average T=44.2% (λ=400-1100 nm)
  - $\alpha > 1\times10^5$ cm^{-1} (λ<540 nm)
  - Bandgap=1.39 eV
  - Urbach Energy=4.1 meV

02 Electrical Characterization, Conclusions and Perspectives

Sample	Carrier Concentration (cm^{-3})	Hole Mobility ($cm^2V^{-1}s^{-1}$)	Sheet resistance($\Omega \cdot sq^{-1}$)
O10	1.75×10^{15}	11.1	1.90×10^{7}
O15	3.30×10^{17}	2.43	1.10×10^{6}
O20	2.10×10^{18}	0.444	1.13×10^{6}
[2]	10^{16}	20	/

Conclusions:

- P-type CuO films with high absorption coefficient and tunable bandgap from 1.39 to around 1 eV.
- Best-performed O10 sample with low Urbach energy, good carrier concentration, and excellent hole mobility.

Perspectives:

- Large-area photodetection materials in the UV and near visible spectral range for future photodetector applications.
- Post-annealing is expected to further improve the performances of CuO thin films.

Thank you

References:
[1] Zeng, Xi, et al. "Structural and Opto-electronic characterization of CuO thin films prepared by DC reactive magnetron sputtering." *Journal of Materials Science: Materials in Electronics* (2020): 1-11.
[2] Kim, Hong-Sik, et al. "Optical and electrical properties of Cu-based all oxide semi-transparent photodetector." *Applied Physics Letters* 109.10 (2016): 101902.

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