Characterizing MBE grown $SrMoO_3$ thin films as a transparent conductor

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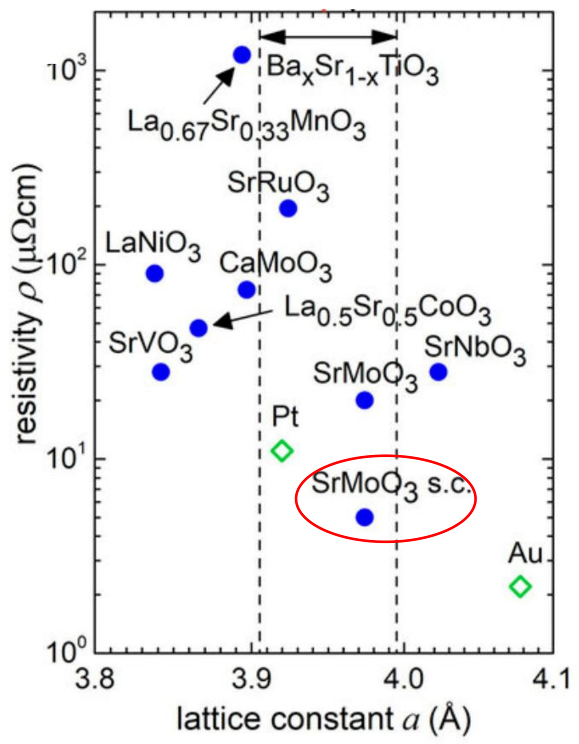
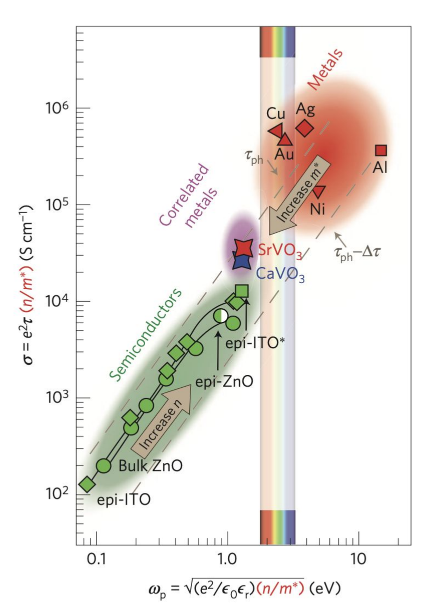
Introduction of $SrMoO_3$



P. Salg et al. APL Mater. **7**, 051107 (2019).

- $SrMoO_3$ is the most conducting perovskite oxide and also optically transparent.
- As a result, it is categorized as a Transparent Conducting Oxide (TCO) and suitable as a transparent bottom electrode for other perovskites.



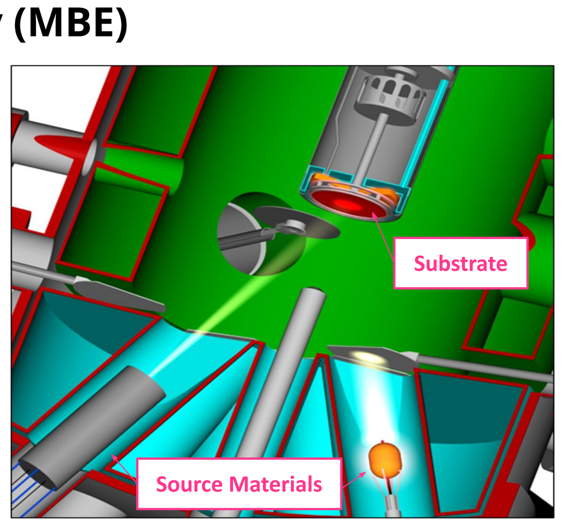
[1] Zhang et al. Nature Materials **15** (2016) 204-211

- **Metals** have good electrical conductivity but are opaque.
- **Degenerately doped semiconductors** are optically transparent but have low electrical conductivity
- **Correlated metals** like $SrMoO_3$ are both transparent and good conductors.

Methodology

Molecular-Beam Epitaxy (MBE)

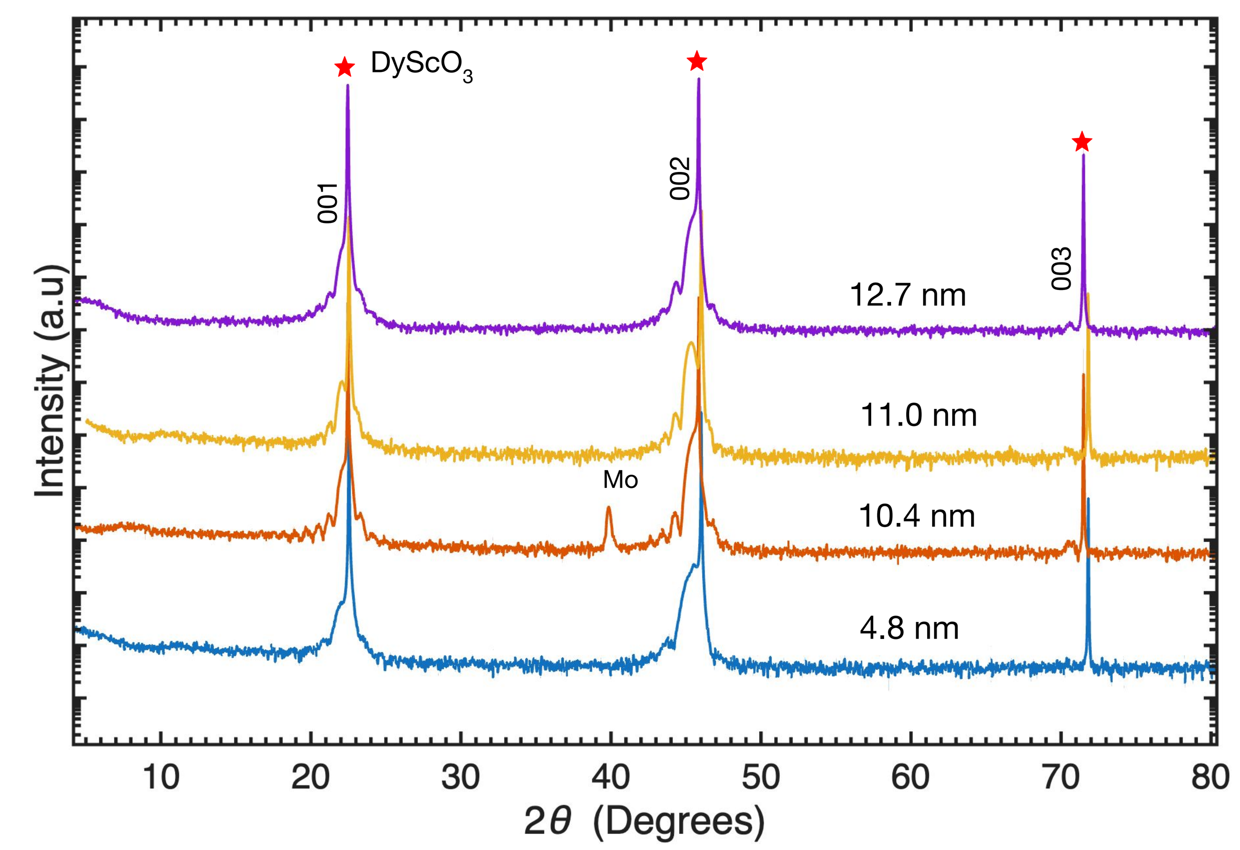
$SrMoO_3$ thin films were grown using MBE, a deposition technique that uses molecular beams from a heated source in ultra-high vacuum. MBE provides flexibility and unparalleled control over growth parameters.



Growth Parameters	
Substrate temperature	1250 ℃
Sources	Sr, MoO_3
Background Pressure	5 x 10^{-8} torr (2 x 10^{-8} from leak valve)
Substrate	$DyScO_3$ (110)
Lattice Mismatch	0.3% compressive

Results

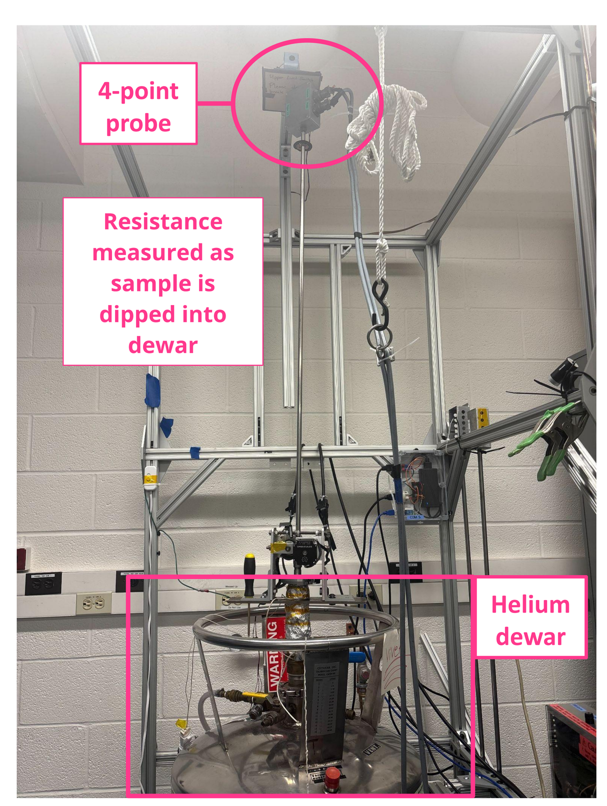
Structural Characterization - X-Ray Diffraction

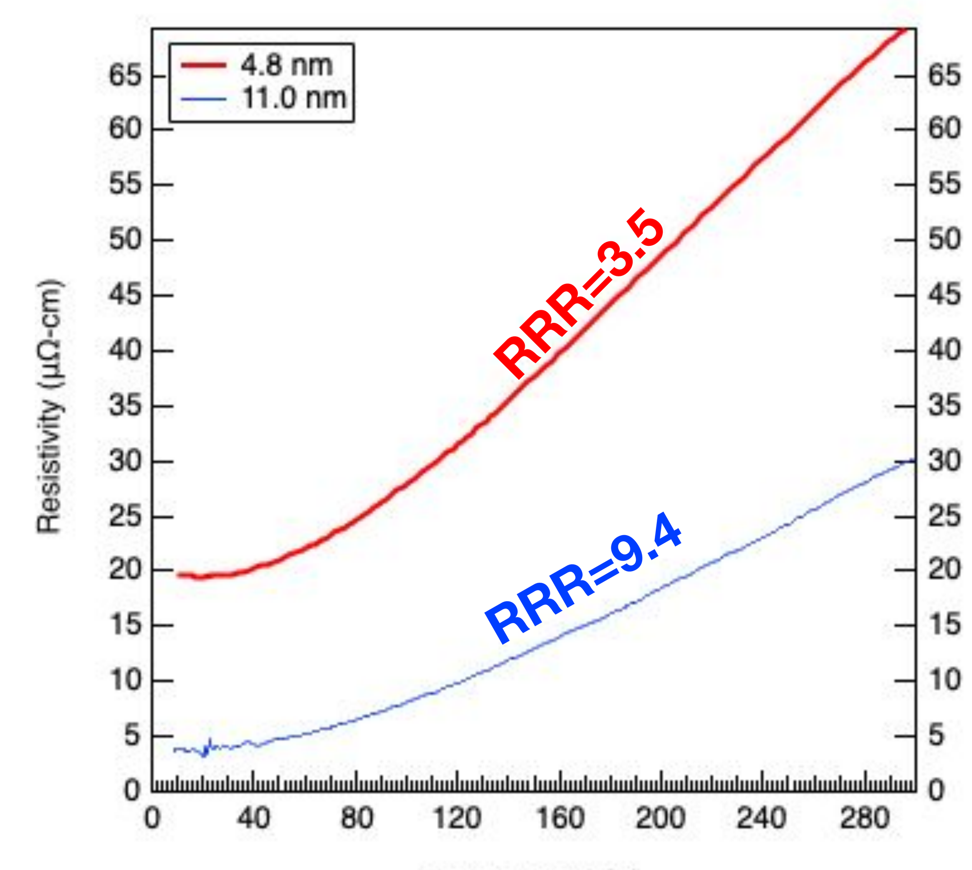


2Θ-ω scans

- Phase pure $SrMoO_3$ films of varying thicknesses were grown on $DyScO_3$ substrates.
- All films were grown at 1250 ℃, in a Sr excess regime.
- Fringes indicate sharp interface between film and substrate, as well as good crystalline quality.
- Peak around 40° (Orange curve) is Molybdenum metal, formed possibly due to source instability.

Transport- Resistivity vs.Temperature



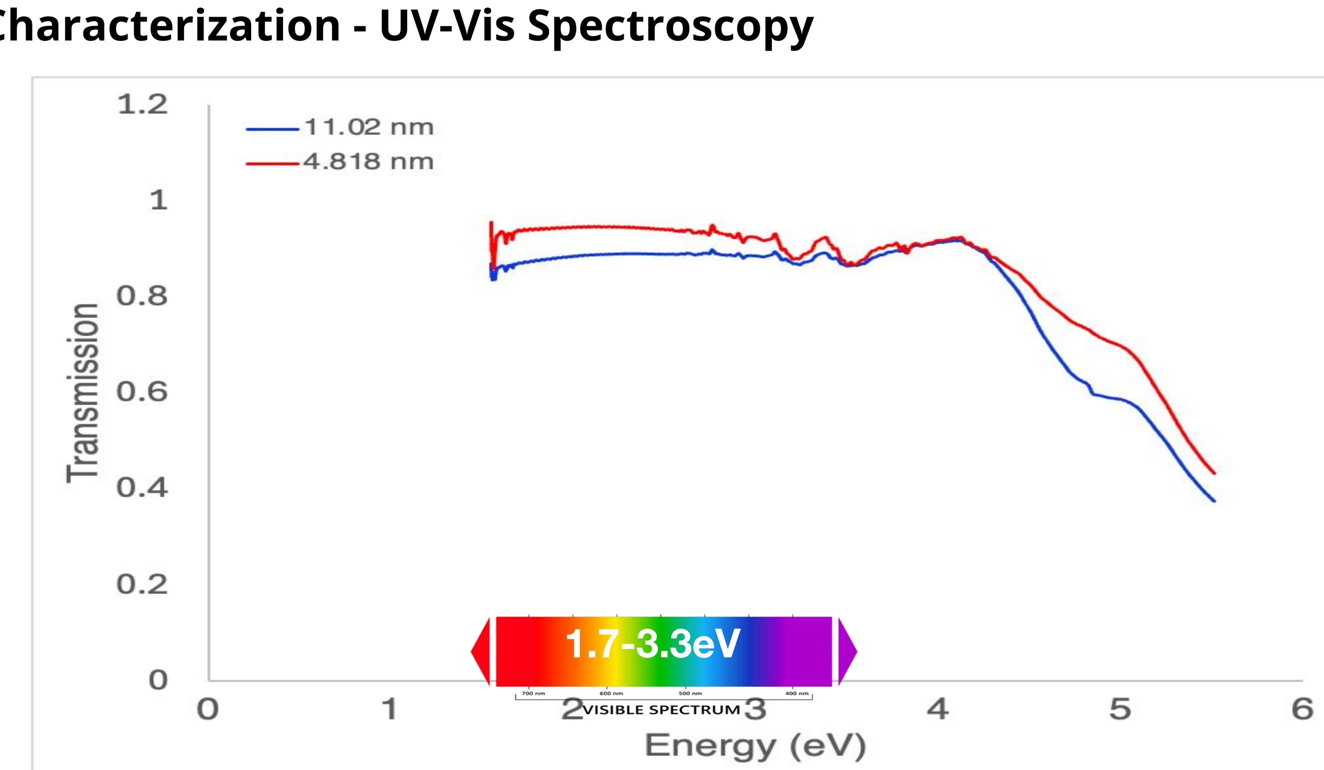


Residual Resistivity Ratio (RRR)

- Ratio of a material's resistivity at room temperature to its resistivity at low temperatures
- Higher the RRR = less defects in the sample.
- RRR is record for $SrMoO_3$ thin films, but has higher room temperature resistivity compared to those in literature.

→ Future work= Improve on these results by improving stability of MoO_3 source and grow in lower background pressures.

Optical Characterization - UV-Vis Spectroscopy



- The thinner film exhibits a higher transmission than the thicker film.
- Films are optically transparent within visible regime.
- In the future, we hope to simulate the optical spectra of $SrMoO_3$ and measure other energy regimes.

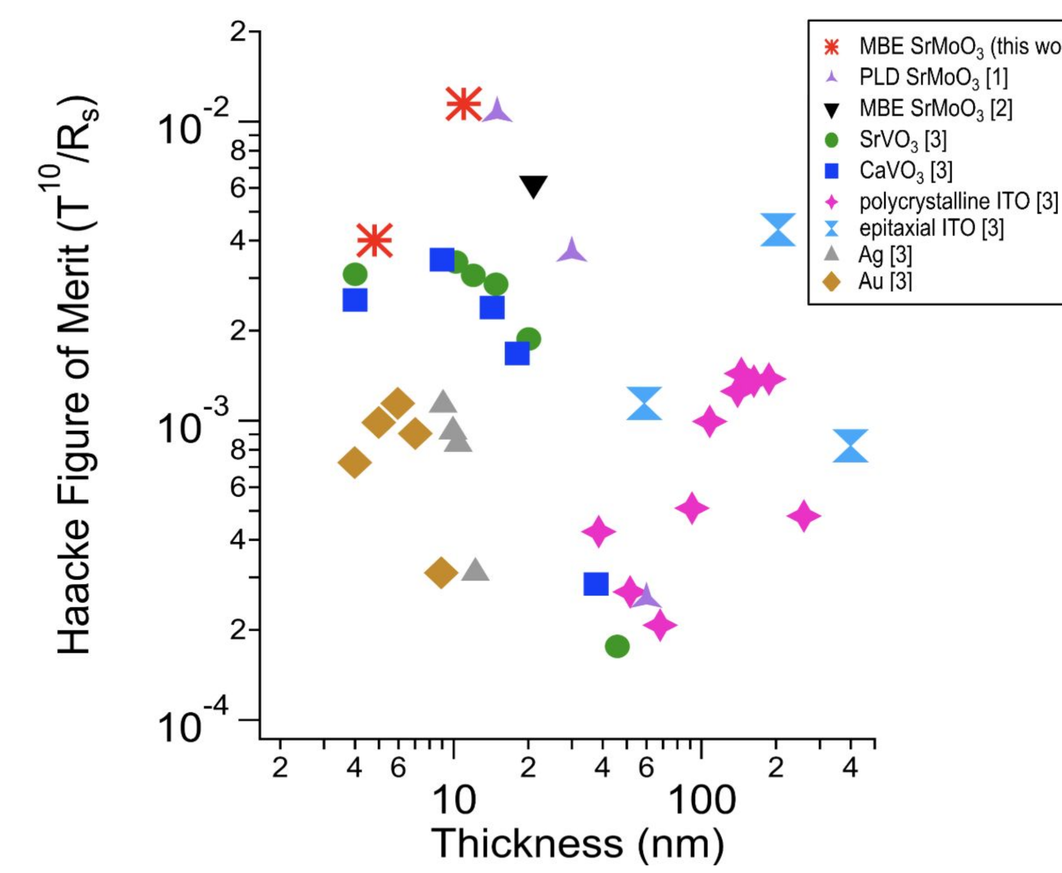
Conclusions

Haack Figure of Merit (FOM):

$$\Phi_{TC} = \frac{T^{10}}{R_s}$$

- T- transmission at 550 nm
- Rs- sheet resistance

Higher the Haacke FOM = better TCO.



Conclusions

- Successfully grew $SrMoO_3$ thin films by MBE.
- Our best film had a RRR of 9.4 and room temperature resistivity of 30 μΩ-cm.
- Our $SrMoO_3$ films have a high Haacke FOM, further validating that $SrMoO_3$ is a promising TCO.

In the future, we aim to compare more $SrMoO_3$ Haacke FOM to other correlated metal oxides.

Acknowledgments

Thank you to my mentor Anna Park, collaborator Vivek Anil, and Principal Investigator Dr. Darrell Schlom for their guidance and encouragement throughout this project. This work is funded by the National Science Foundation (NSF) Platform for the Accelerated Realization, Analysis, and Discovery of Interface Materials (PARADIM) and PARADIM Research Experience for Undergraduates. In addition thank you to NSF Partnerships for Research and Education in Materials (PREM) for funding my participation in this program.

References

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[2] Radetinac et al. *J. Appl. Phys.* **119**, 055302 (2016).
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