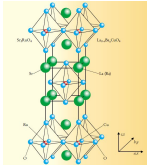
Epitaxial Growth and Characterization of Layered Ruddlesden-Popper $Sr_{n+1}Ru_nO_{3n+1}$

Ian Mercer[1], Neha Wadehra[2], Darrell Schlom[2]
[1]*Materials Science and Engineering, North Carolina State University*
[2]*Department of Materials Science and Engineering, Cornell University*

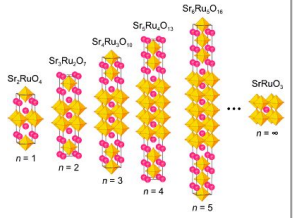
Introduction



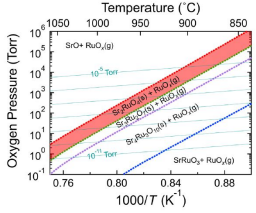
Y. Maeno, et al. Physics Today (2001)

- Strontium Ruthenate was a prospective high T_C superconductor due to its similar crystal structure and conduction to cuprates
- Predicted spin triplet superconductivity
- Wide range of magnetic ordering from changing stoichiometry

- Sr_2RuO_4 and $SrRuO_3$ have been explored thoroughly, but Ruddlesden-Popper (RP) phases remain unexplored
- By varying number of perovskite layers magnetization can change
- Possible interesting phenomena undiscovered



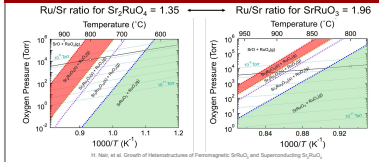
D. Schlom, et al. Journal of the American Ceramic Society (2008)



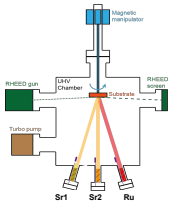
H. Nair, et al. APL Materials , (2018)

- Use thermodynamics to guide growths
- Growth of RP phase is function of growth temperature and oxygen pressure
- Lack of data for RP phases
- Mimic crystal structure of higher RP phase using Sr_2RuO_4 and $SrRuO_3$ as building blocks

Methods



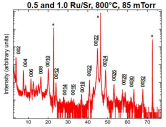
H. Nair, et al. Growth of Heterostructures of Ferromagnetic $SrRuO_3$ and Superconducting Sr_2RuO_4



https://capricorn.bc.edu/wp/zeljkoviclab/research/molecular-beam-epitaxy-mbe/

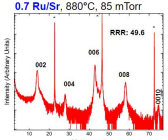
- Vary Ru/Sr ratio for Sr_2RuO_4 and $SrRuO_3$ growth, keeping temperature and oxygen pressure constant
- Supply excess Ru for adsorption control
- $SrTiO_3$ (001) substrates are used due to relative lattice match to two phases

Results

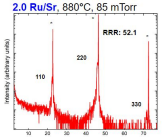


- Grew n=5 member of RP series using stoichiometric flux control growth
- Next, grow in adsorption control flux growth to avoid n=4 impurities

Sr_2RuO_4

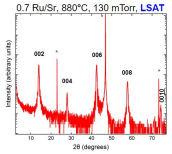


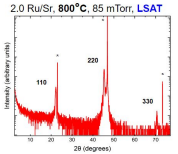
$SrRuO_3$

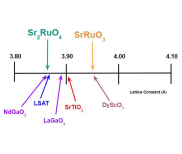


- Sr_2RuO_4 and $SrRuO_3$ both can be grown at 880°C and 85 mTorr on STO (001) in adsorption control flux growth mode

Results







- LSAT (001) substrate improves Sr_2RuO_4 quality further due to lattice matching and may help improve the heterostructures
- $SrRuO_3$ growths to be checked on LSAT (001) at higher growth temperatures

Conclusions

- Sr_2RuO_4 and $SrRuO_3$ building blocks can be used to grow higher n-members of the $Sr_{n+1}Ru_nO_{3n+1}$ RP series eliminating the thermodynamic bottleneck
- More growth conditions in adsorption controlled growth mode needs to be explored to get phase pure films

Acknowledgements

I would like to thank my mentor Neha, Darrell Schlom for allowing me to do great research in his group, and NSF for allowing the PARADIM program to do groundbreaking research.

References

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H. Nair, et al. APL Materials **6**, 046101 (2018)
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