Characterization of Cubic Perovskite $BaRuO_3$ Under Varying Degrees of Epitaxial Strain

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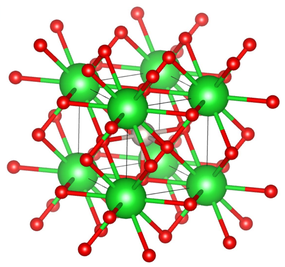
Background

Ruthenate perovskites are, as a family, interesting and deserving of investigation, as they demonstrate non-trivial variation in their electromagnetic properties depending on the choice of cation present in their crystal lattice, with some even being superconductors.

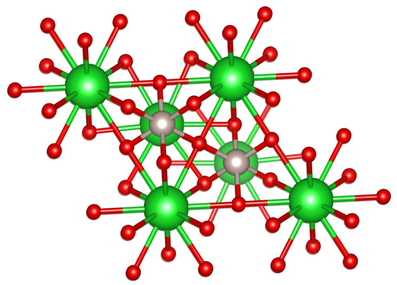
Compound	Cation	Ground state
$CaRuO_3$	Ca^{2+}	Paramagnetic non-fermi liquid metal
Ca_2RuO_4	Ca^{2+}	Antiferromagnetic Mott insulator
$SrRuO_3$	Sr^{2+}	Ferromagnetic metal
Sr_2RuO_4	Sr^{2+}	Odd-parity superconductor
$BaRuO_3$	Ba^{2+}	Ferromagnetic metal
Ba_2RuO_4	Ba^{2+}	Paramagnetic metal + potential



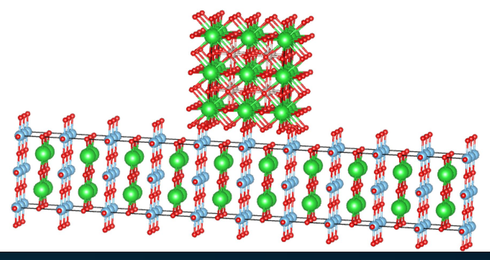
$BaRuO_3$ is of particular interest, as it can assume a cubic crystal structure, allowing its electronic structure to be characterized more easily.

This cubic phase is also of interest for being, to our knowledge, the most barophilic material ever to be stabilized through the use of epitaxial growth. This stabilization is necessary, as, at standard conditions, the crystal prefers to take on a hexagonal structure.

This tendency can be overcome through the aforementioned method, where the constituents of the crystal are vaporized and deposited on a substrate, adopting that substrate's crystal structure.



This induces an epitaxial strain on the film, as it is forced to adopt a smaller lattice parameter.

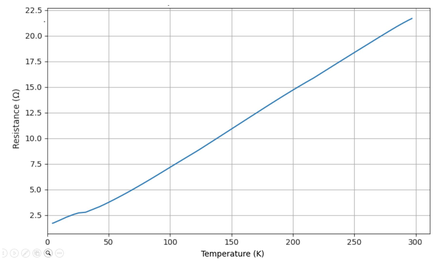


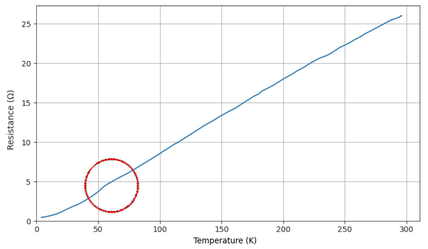
Ferromagnetic anomaly

Initial growth of barium ruthenate on a $TbScO_3$ substrate demonstrated a lack of a ferromagnetic transition, evinced on a resistance vs temperature graph by a notable kink. This was anomalous, as prior literature regarding bulk samples indicated a transition in the vicinity of 50 K.

Further investigation of material Grown on $SmScO^3$ revealed a return of the transition.

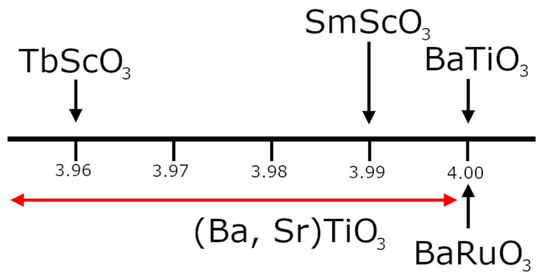
As X-ray diffraction scans revealed the films to be of excellent quality, the only explanation for the variation in ferromagnetism was the difference in strain experienced by films growing on either substrate.





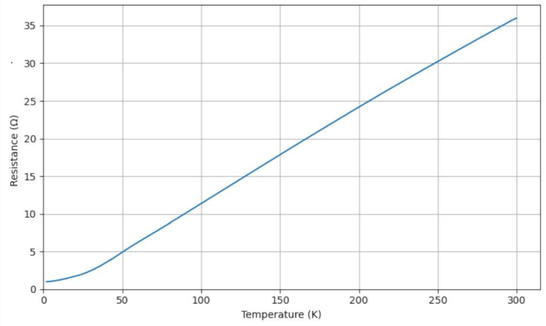
Strain variation

As the above experiments demonstrated a change in ferromagnetic transition temperature dependent on the strain, further experiments were proposed to investigate the nature of this change by growing $BaRuO_3$ on a collection of $BaTiO^3$ substrates doped with strontium to produce a range of differing strains.

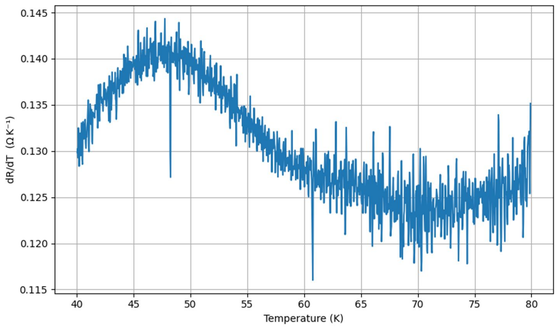


Results and conclusions

When a sample was grown on a pseudosubstrate of pure barium titanate as a preliminary step, it demonstrated no obvious kink, despite the near complete lack of strain.



When the derivative was taken of the region where a transition was expected to occur, evidence of a faint kink was detected.



Due to the faintness of this kink, Hall measurements will be required to confirm the existence of a transition.

Future work

Future work will consist of taking hall measurements of the sample on barium titanate to confirm or disprove the existence of a ferromagnetic transition.

Following that, more samples will be grown on scandate substrates in order to avoid the sample quality issues faced here.