Electronic Reconstruction and Anomalous Hall Effect (AHE) in the $LaAlO_3/SrRuO_3$ Heterostructure

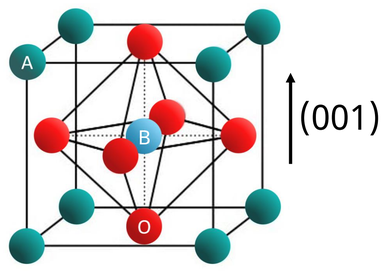
Poster Prize
GHN Workshop
Würzburg, 2023

Merit Spring[1], Ji Soo Lim[1], Martin Kamp [1,2], Matthias Schmitt [1,3], Deepnarayan Biswas [3], Louis Veyrat [4], Pavel Potapov [4], Axel Lubk [4], Bernd Büchner [4], Tien-Lin Lee [3], Michael Sing[1] and Ralph Claessen[1]

[1]Physikalisches Institut and Würzburg-Dresden Cluster of Excellence ct.qmat, 97074 Würzburg, Germany
[2] Wilhelm Conrad Röntgen-Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany
[3] LDiamond Lightsource Ltd., Harwell Science and Innovation Campus, Didcot Oxfordshire OX11 0DE, UK
[4] Leibniz Institute for Solid State and Materials Research, 01069 Dresden, Germany

$LaAlO_3/SrRuO_3$-System

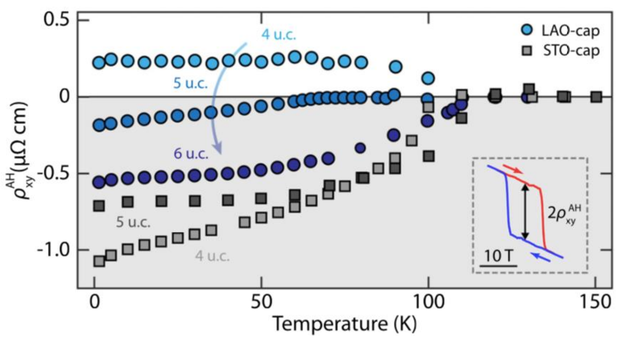
- Epitaxial growth on a $SrTiO_3$ (STO) substrate **$SrRuO_3$** (SRO): alternating layers of $Sr^{2+}O^{2-}$ and $Ru^{4+}(O^{2-})_2$ → **non-polar**
- **$LaAlO_3$** (LAO): alternating layers of $La^{3+}O^{2-}$ and $Al^{3+}(O^{2-})_2$ → **polar**



Perovskite structure: ABO_3

→ possible electronic reconstruction → 2D charge pinning at the interface of ferromagnetic, metallic SRO and LAO [1,2]

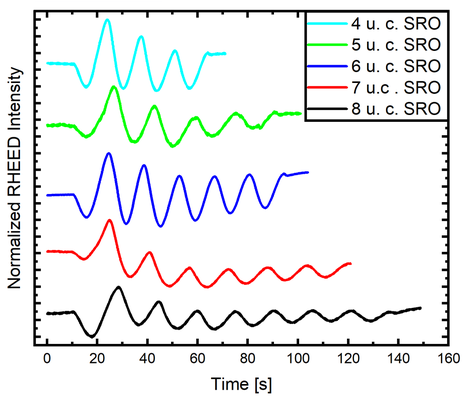
Topological Phase Transition

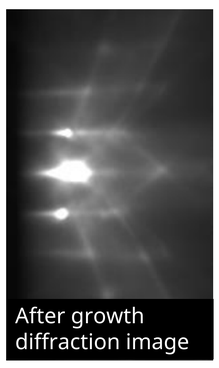


Caviglia group [1]:
Topological phase transition of SRO band structure depending on film thickness
→ sign change of AHE ρ_{xy}^{AH}

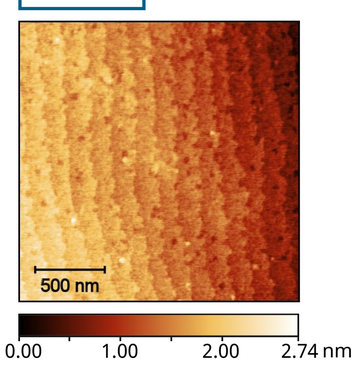
Structural Properties

RHEED

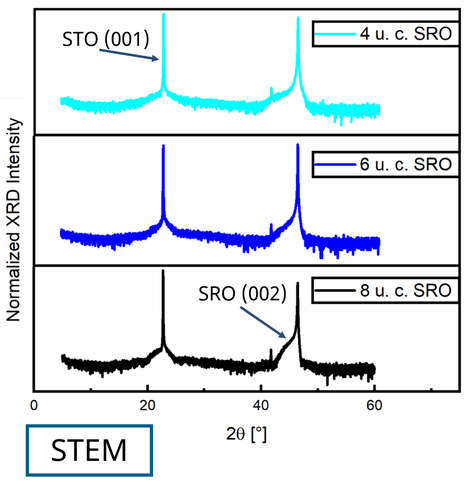




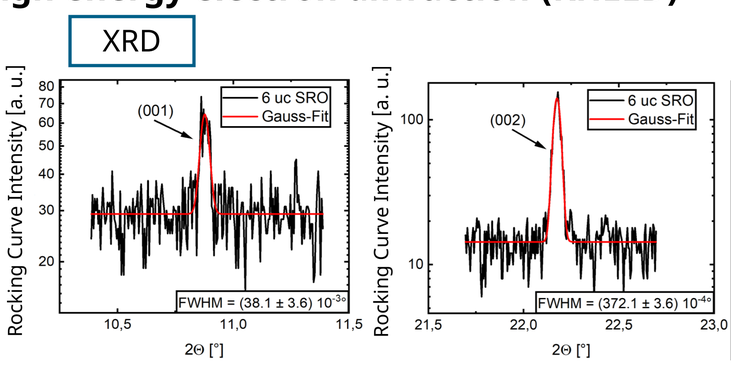
AFM



- Growth of high quality thin films by **pulsed laser deposition (PLD)**
- Monitoring by **reflection high energy electron diffraction (RHEED)**

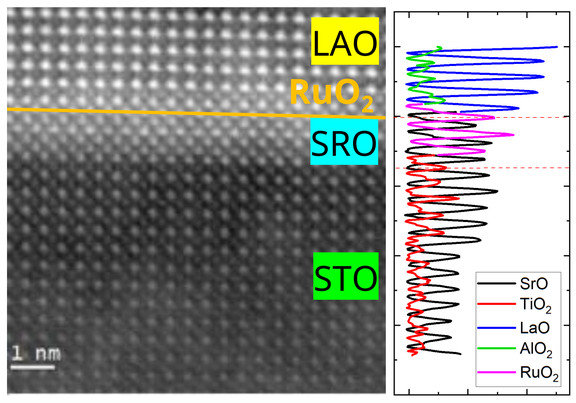


XRD



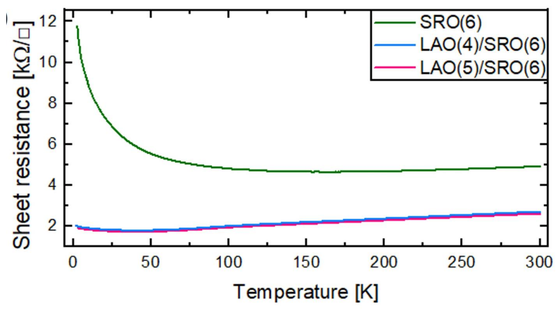
- *c*-axis lattice parameter: $a_{SRO} \approx 4$ Å
- Good crystalline quality

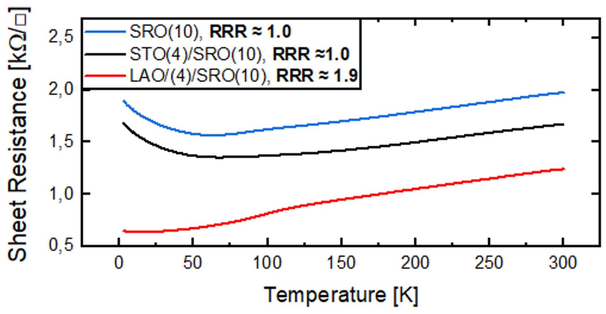
STEM



- SRO usually SrO-terminated [2]
- Capping with LAO: SrO desorbs [1] → RuO_2 termination
- B-cation intermixing at SRO/STO (from fitting of cross sections)

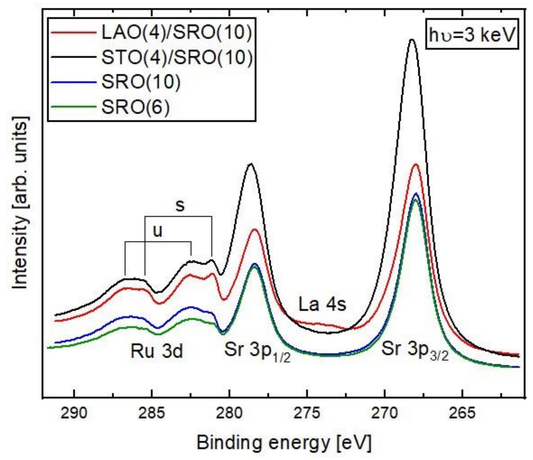
Transport Measurements

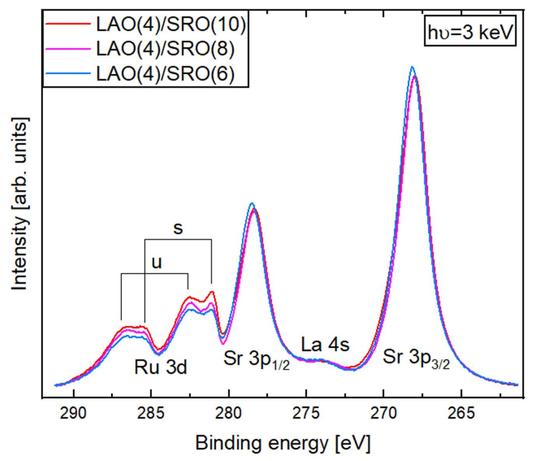


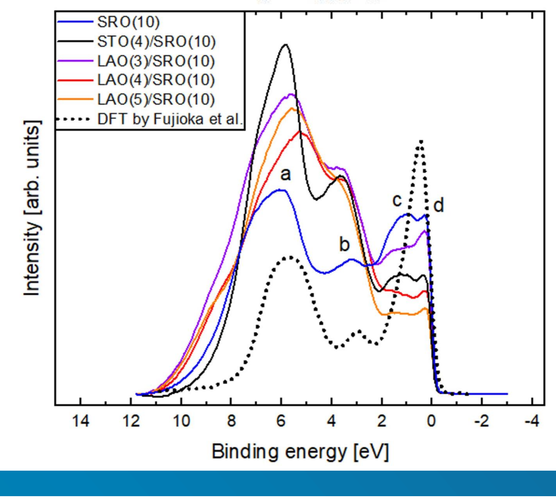


- SRO undergoes thickness dependent metal-insulator transition [3]
- For 6 uc and 10 uc SRO: ≥ 4uc LAO capping drives SRO films metallic

Photoemission Study



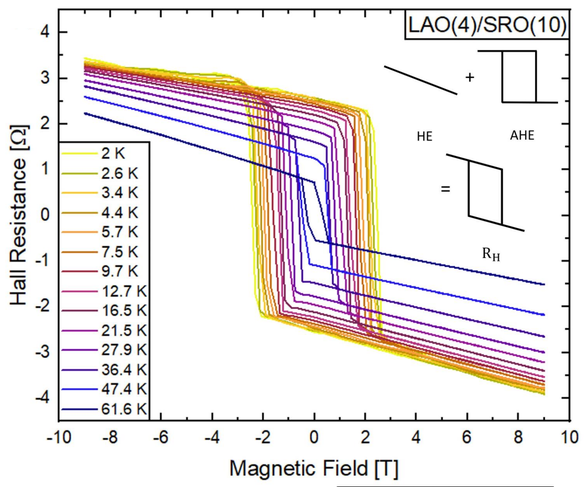


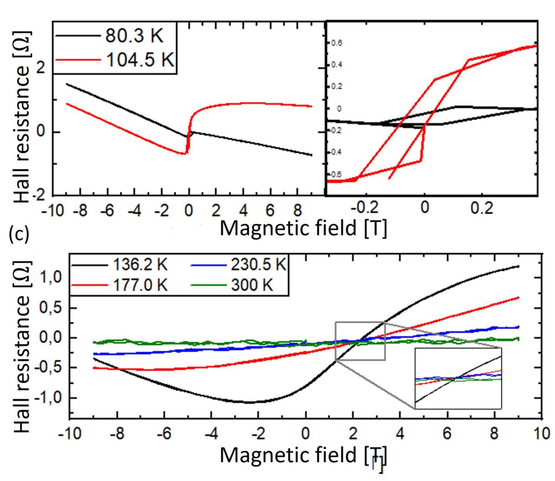


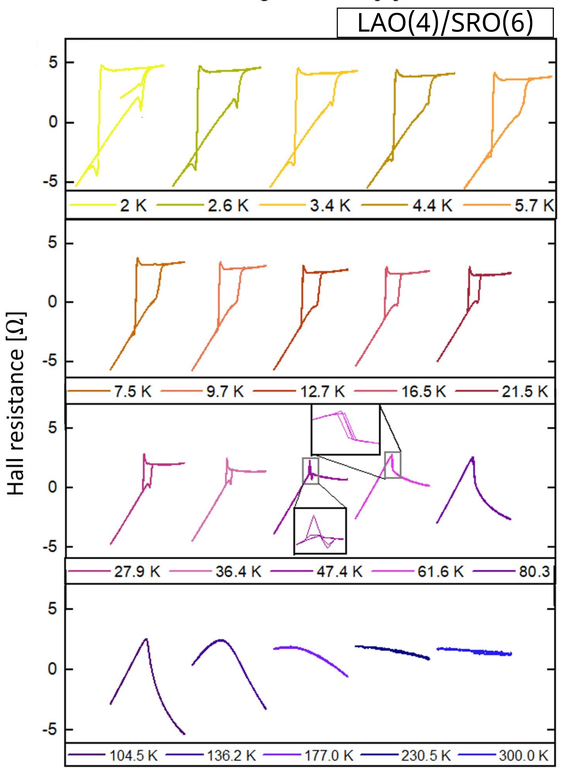
- Double peak structure can be understood in terms of correlated electrons
- Screened feature (s) indicates metallicity

→ Capping influences Ru 3d states

Anomalous Hall Effect (AHE)







- Theory in [1] : AHE of intrinsic origin → non-zero Berry curvature
- Temperature-:dependent sign-change in close proximity to the magnetic phase transition
- Change of slope indicates change of carrier type
- Inverted AHE for LAO(4)/SRO(6) compared to LAO(4)/SRO(10) → change of film thickness induces topological phase transition

Summary

- Insulating but polar LAO-capping pushes SRO (deeper) into the metallic regime thereby modifying the electronic ruthenium states
- Strong evidence for electronic reconstruction induced by the LAO-capping, accompanied by a topological phase transition as function of SRO thickness

References
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[3] G. Rijnders, D. H. A. Blank, Appl. Phys. Lett. **84**, 505 (2004)
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