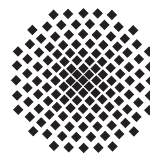


# Stuttgarter Physikalisches Kolloquium

Max-Planck-Institut für Festkörperforschung  
Max-Planck-Institut für Intelligente Systeme  
Fachbereich Physik, Universität Stuttgart

Ansprechpartner: Andreas Schnyder  
E-Mail: A.Schnyder@fkf.mpg.de  
Telefon: 0711 - 689-1553



Dienstag, 23. Oktober 2018

16.15 Uhr

Hörsaal 2D5

Stuttgarter Max-Planck-Institute, Heisenbergstraße 1, 70569 Stuttgart-Büsnau

## Tuning the Band Structure of Ruthenates with Strain and Dimensionality

Darrell G. Schlom<sup>1,2</sup>

<sup>1</sup> Department of Materials Science and Engineering, Cornell University, Ithaca, NY, USA

<sup>2</sup> Kavli Institute at Cornell for Nanoscale Science, Ithaca, NY, USA

### Abstract

Molecular-beam epitaxy (MBE) is renowned for preparing semiconductor heterostructures with high purity, high mobility, and exquisite control of layer thickness at the atomic-layer level. In recent decades it has become the definitive method for the preparation of oxide quantum materials as well. In this talk I will describe the use of MBE to tune the band structure of ruthenates. Ruthenates with perovskite and perovskite-related structures host a remarkably diverse class of exotic quantum phases ranging from spin-triplet superconductivity, ferromagnetism, metamagnetism, spin-density waves, antiferromagnetism, and quantum criticality – all with the same basic building block of corner-sharing  $\text{RuO}_6$  octahedra containing  $\text{Ru}^{4+}$  ions. Using thermodynamics we identify appropriate conditions for the growth of ruthenate films<sup>1</sup> and then exploit strain engineering and dimensionality to tune the band structure and properties of  $\text{SrRuO}_3$ <sup>1,2</sup> and  $\text{BaRuO}_3$ <sup>3</sup> with the perovskite structure as well as their two-dimensional counterparts  $\text{Sr}_2\text{RuO}_4$ <sup>4,5</sup> and  $\text{Ba}_2\text{RuO}_4$ .<sup>4</sup> The misfit strain is imposed by underlying substrates to strain these ruthenate thin films to percent levels. The band structure is revealed by high-resolution angle-resolved photoemission (ARPES) on pristine as-grown surfaces of these complex oxides made possible by a direct ultra-high vacuum connection between the MBE and ARPES.<sup>6</sup> Our work demonstrates the possibilities for utilizing strain engineering as a disorder-free means to manipulate emergent properties and many-body interactions in correlated materials.

1. H.P. Nair, Y. Liu, J.P. Ruf, N.J. Schreiber, S.-L. Shang, D.J. Baek, B.H. Goodge, L.F. Kourkoutis, Z.K. Liu, K.M. Shen, and D.G. Schlom,

"Synthesis Science of  $\text{SrRuO}_3$  and  $\text{CaRuO}_3$  Epitaxial Films with High Residual Resistivity Ratios," *APL Materials* **6** (2018) 046101.

2. D.E. Shai, C. Adamo, D.W. Shen, C.M. Brooks, J.W. Harter, E.J. Monkman, B. Burganov, D.G. Schlom, and K.M. Shen, "Quasiparticle Mass Enhancement and Temperature Dependence of the Electronic Structure of Ferromagnetic  $\text{SrRuO}_3$  Thin Films," *Physical Review Letters* **110** (2013) 087004.

3. B. Burganov, H. Paik, J.P.C. Ruff, D.G. Schlom, and K.M. Shen (unpublished).

4. B. Burganov, C. Adamo, A. Mulder, M. Uchida, P.D.C. King, J.W. Harter, D.E. Shai, A.S. Gibbs, A.P. Mackenzie, R. Uecker, M. Bruetzsch, M.R. Beasley, C.J. Fennie, D.G. Schlom, and K.M. Shen, "Strain Control of Fermiology and Many-Body Interactions in Two-Dimensional Ruthenates," *Physical Review Letters* **116** (2016) 197003.

5. H.P. Nair, J.P. Ruf, N.J. Schreiber, L. Miao, M.L. Grandon, D.J. Baek, B.H. Goodge, J.P.C. Ruff, L.F. Kourkoutis, K.M. Shen, and D.G. Schlom, "Demystifying the Growth of Superconducting  $\text{Sr}_2\text{RuO}_4$  Thin Films," *APL Materials* (in press).

6. D.G. Schlom and K.M. Shen, "Oxide MBE and the Path to Creating and Comprehending Artificial Quantum Materials," *Applied Surface Science* (in press).