IAP Seminar

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Create and Control Novel Phases in Heterostructures of Transition Metal Oxides

Transition Metal Oxides (TMOs) exhibit unique and multifunctional physical phenomena (such as high-temperature superconductivity, colossal magnetoresistance, metal-insulator transitions, etc.) directly related to the spin and orbital degrees of freedom of the transition metal d-states and their interplay with the lattice. Importantly, the iso-structure of TMOs permits realization of hetero-structures generating at their surfaces and interfaces new physical matters that radically differ from those of the constituent bulk materials. Therefore, to fully explore the potential of modern quantum and hybrid materials based on TMO the first worldwide experimental setup combining Pulse Laser Deposition and Angle Resolved Photoemission (ARPES) has been designed at the SIS beamline (Swiss Light Source, Paul Scherrer Institut). Presently, this set up is being extended with Molecular Beam Epitaxy (MBE) chamber and Scanning Tunnelling Microscope (STM). With this capability, the control of structure and morphology of ultrathin films down to one unit cell thickness prior to the spectroscopy experiments will be secured.

Thanks to the unique combination of growth and spectroscopy at SIS beam line two methods to manipulate properties of TMO based hetero-structures have been established:

1. **Altering orbital ordering and controlling properties of the 2DEG at titanates surfaces**.

Employing ARPES diverse ways have been established to manipulate the 2DEG and, consequently, electronic properties of titanates surfaces ($SrTiO_3$ in bulk and film forms [1, 2, 3], TiO_2-anatase [3] and $CaTiO_3$ [4] films).

2. **Tuning electronic phases in ultra-thin $NdNiO_3$ films via a strain and a proximity to the magnetic layer.**

The electronic structure of NNO films grown solely and in proximity to magnetically ordered manganite layers has been studied. Combining the ARPES experimental data with the theoretical calculations, we found that the insulator phase in ultra-thin NNO films is destabilized probably due to quenching of anti-ferromagnetic (AF) order via proximity to the ferromagnetic manganite layer [4, 5].

References:
[1] N. C. Plumb, M. Salluzzo, E. Razzoli, M. Månsson, M. Falub, J. Krempasky, C. E. Matt, J. Chang, J. Minár, J. Braun, H. Ebert, B. Delley, K.-J. Zhou, C. Monney, T. Schmitt, M. Shi, J. Mesot1, C. Quitmann, L. Patthey, M. Radović, ***Mixed dimensionality of confined conducting electrons in the surface region of $SrTiO_3$***, Phys. Rev. Lett. 113, 086801 (2014).
[2] A. F. Santander-Syro, F. Fortuna, C. Bareille, T. C. Rodel, G. Landolt, N. C. Plumb, J. H. Dil, and M. Radovic, ***Giant spin splitting of the two-dimensional electron gas at the surface of SrTiO3***, Nature Materials 13, 1085–1090 (2014).
[3] Z. Wang, Z. Zhong, S. McKeown Walker, Z. Ristic, J.-Z. Ma, F. Y. Bruno, S. Riccò, G. Sangiovanni, G. Eres, N. C. Plumb, L. Patthey, M. Shi, J. Mesot, F. Baumberger and M. Radovic, ***Atomic scale lateral confinement of a two-dimensional electron liquid in anatase TiO_2***, Nano Letters 17 (4), pp 2561–2567 (2017).
[4] Stefan Muff, Mauro Fanciulli, Andrew P. Weber, Nicolas Pilet, Zoran Ristic, Zhiming Wang, Nicholas C. Plumb, Milan Radovic, J. Hugo Dil, ***Observation of a two-dimensional electron gas at $CaTiO_3$ film surfaces***, Applied Surface Science, Volume 432, 41-45 (2017).
[5] R. S. Dhaka, T. Das, N. C. Plumb, Z. Ristic, W. Kong, C. E. Matt, N. Xu, K. Dolui, E. Razzoli, M. Medarde, L. Patthey, M. Shi, M. Radovic, and J. Mesot, ***Tuning the metal-insulator transition in $NdNiO_3$ heterostructures via Fermi surface instability and spin-fluctuations***, Phys. Rev. B 92, 035127 (2015).
[6] Z. Ristic, R. S. Dhaka, T. Das, Z. Wang, C. E. Matt, N. C. Plumb, M. Naamneh, M. Shi, L. Patthey, M. Radovic, and J. Mesot, ***Quenching Insulator phase in ultra-thin $NdNiO_3$ films via the proximity to the magnetic layer,*** under review 2018.

All interested colleagues are welcome to this seminar lecture (45 min. presentation followed by discussion)

Friedrich Aumayr
(LVA-Leiter)

Ulrike Diebold
(Seminar Chair)