Colloquium on Solid-State Physics

Date: Thursday, Dec. 19, 2013
Time: Coffee, Tea and cookies: 17:00 h
Presentation: 17:15 h

Place: Hörsaal HS 3
Physik - Department
Technische Universität München

Seminar of the Collaborative Research Centre/Transregio TRR 80:

X-ray spectroscopy of oxide heterointerfaces

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Oxide heterointerfaces are of great interest due to their provision of switchable 2DEG systems which emerge at the (buried) interface between insulating transition metal oxides. Complex oxides possess an impressive array of different quantum states of matter such as magnetism, unconventional superconductivity and ferroelectricity, and coupling this to the engineering control offered in oxide heterointerfaces makes this a highly competitive platform for the development of oxide electronics technology [1]. Modern synchrotron-based X-ray spectroscopies are able to provide direct information on the electronic structure of buried interfaces, and this seminar will focus on what we can learn from these techniques in the context of state-of-the-art oxide heterointerface systems.

In the first part of the seminar, I will present our recent spectroscopic work on thin films grown by our colleagues in Twente on bulk $SrTiO_3$ substrates. Expitaxial overlayers of $LaAlO_3$ are grown, and remain uncapped [2], or are capped by $SrTiO_3$ or by $SrCuO_2$+$SrTiO_3$. In the latter, record mobilities are achieved thanks to the effective elimination of oxygen vacancies [3]. Exploiting the elemental and electrostatic sensitivity inherent to core level spectroscopies, we have investigated not only the structure of the ultrathin O vacancy scavenging layers [3], but can provide a complete energy level scheme for the thin film stacks. There is a clear correlation between the absence of impurity-level-induced transport due to O vacancies and the presence of large band offsets at the $SrTiO_3$ / $LaAlO_3$ interface, which can exceed an electronvolt.

In the second part, I switch to $LaAlO_3$ / $SrTiO_3$ systems in which the $SrTiO_3$ thickness is the main variable, with films being grown on bulk $NdGaO_3$ by our collaborators in Singapore. In this case, the Ti 3d orbital energy scheme is inverted compared to the systems in part 1, and we are able to provide a detailed view of the electrostatics within the $SrTiO_3$ layer. Our spectroscopic data clearly signal the presence of confined Ti3d carriers at the $NdGaO_3$|$SrTiO_3$ interface, but interestingly, a transition seen from strongly insulating to weak localization behaviour in transport is seen to correlate with the emergence of a second confined carrier system at the $SrTiO_3$|$LaAlO_3$ interface. I will compare our data to DFT+U calculations carried out in the group of Rossitza Pentcheva at LMU.

This research is a collaboration between the UvA: E. Slooten, B. Shi, B. Zwartsenberg, E. van Heumen, J. B. Goedkoop; HZB-BESSY: M. Gorgoi, P. Miedema, R. Abrudan; U. Twente: Z. Zhong, H. Molegraaf, P. Eerkes, S. Wenderich, J. Kleibeuker, M. Huijben, G. Rijnders, G. Koster, A. Brinkman, D. Blank, P. Kelly, H. Hilgenkamp; NUS: A. Annadi, Ariando; and LMU: D. Doennig, J. Munding and R. Pentcheva. Funding is provided by the FOM foundation, NWO and the EU (beamtime access).

[1] *Interface physics in complex oxide heterointerfaces*, P. Zubko *et al.*, Annu. Rev. Condens. Matter Phys. 2 , 141-165 (2011)

[2] *Hard x-ray photoemission and density functional theory study of the internal electric field in $SrTiO_3$/$LaAlO_3$ oxide heterostructures,* E. Slooten *et al.*, Phys. Rev. B**87**, 085128 (2013)

[3] *Defect engineering in oxide heterostructures by enhanced oxygen surface exchange,* M. Huijben *et al.*, Advanced Functional Materials, (2013) doi: 10.1002/adfm.201203355.