DS 5: Thin Oxides and Oxide Layers

Time: Tuesday 14:00–15:15 Location: H3

DS 5.1 Tue 14:00 H3

How to functionalize 2D states at oxide interfaces by controlled redox reaction — •Pia Maria Düring, Andreas Fuhrberg, Timo Krieg, Verena Reva, and Martina Müller — FB Physik, Universität Konstanz, 78457 Konstanz

Oxide electronics provide the key concepts and materials for enhancing silicon-based semiconductor technologies with novel functionalities. In a recent paper, we provide evidence for individually emerging hole- and electron-type 2D band dispersions at Fe-$SrTiO_3$ heterostructures [1]. The emergence of p- or n-type bands is closely linked to the Fe oxidation state which enables the possibility to tune the interface properties to set or even switch between negatively (n) charged electrons or positively (p) charged holes. One of the main processes that controls the interface properties is the oxygen exchange between the film and the substrate. Using our UHV-MBE system, we grow high-quality ultrathin TM (e.g. Fe, Co and Hf) oxide films on $SrTiO_3$ substrates by systematically varying the growth parameters, e.g. (i) growth temperature, (ii) substrate annealing, and (iii) metal film thickness. The present work discusses the effect of different growth parameters on the interfacial properties like oxygen vacancies, the oxidation state of the TM oxide as well as the concentration of defects in $SrTiO_3$, which strongly influences the valence band alignment between electron and hole band bending. In this way, we can effectively control the properties of the 2D interface to ultimately add ferroic functionalities to these confined electronic states.

[1] P. M. Düring et al., Advanced Materials, 2024, 2390217.

DS 5.2 Tue 14:15 H3

Adsorption-controlled growth of α-(Al,Ga)2O3 and β-(Al,Ga)2O3 on Al2O3 by suboxide molecular-beam epitaxy (S-MBE) — •Sushma Raghuvansy[1], Marco Schowalter[1], Alexander Karg[1], Manuel Alonso-Orts[1,2], Martin Williams[1], Stephan Figge[1], Andreas Rosenauer[1,2], Martin Eickhoff[1,2], and Patrick Vogt[1,3] — [1]Institute of Solid-State Physics, University of Bremen, Otto-Hahn-Allee 1, 28359, Bremen, Germany — [2]MAPEX Center for Materials and Processes, University of Bremen, Bibliotheksstraße 1, 28359 Bremen, Germany — [3]Max Planck Institute for solid state research, Heisenbergstraße 1, 70569 Stuttgart, Germany

Gallium oxide (Ga2O3) is a promising ultra-wide band gap semiconductor with extremely high (predicted) breakdown field for high performance power electronics.

α-Ga2O3 is isostructural to α-Al2O3, and allows alloying over the entire composition range from Ga2O3 (x=0) and Al2O3 (x=1) in α-(AlxGa1-x)2O3 [1]. For β-(AlxGa1-x)2O3, range with which Al can be alloyed is $0 < x < 0.61$, which leads to a bandgap range of 4.6-5.9 eV [2].

In this contribution, we demonstrate the growth of high quality α-(Al,Ga)2O3 on Al2O3 (10-10) and Al2O3 (11-20) and β-(Al,Ga)2O3 on Al2O3 (0001) by suboxide molecular beam epitaxy (S-MBE). We investigated the influence of Al flux and growth parameter space of (Al,Ga)2O3 alloys on differently oriented Al2O3 substrates.

[1] R. Jinno et al., Science Advances 7 (2021) [2] T. Oshima et al., Jpn. J. Appl. Phys. 48, 070202 (2009)

DS 5.3 Tue 14:30 H3

Tuning the interlayer coupling in $La_{0.7}Sr_{0.3}MnO_3$ / $LaNiO_3$ multilayers with strong perpendicular-magnetic-anisotropy — •Jörg Schöpf[1], Valentina Piva[1], Paul H. M. van Loosdrecht[1], Padraic Shafer[2], Divine P. Kumah[3,4], Xuanyi Zhang[3,4], Lide Yao[5], Sebastiaan van Dijken[6], and Ionela Lindfors-Vrejoiu[1] — [1]Institute of Physics II, University of Cologne, Cologne, Germany — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, USA — [3]Department of Physics, Duke University, Durham, USA — [4]Department of Physics, North Carolina State University, Raleigh, USA — [5]OtaNano-Nanomicroscopy Center, Aalto University, Aalto, Finland — [6]Department of Applied Physics, Aalto University School of Science, Aalto, Finland

We report on the magnetic interlayer coupling between Ru-substituted $La_{0.7}Sr_{0.3}MnO_3$ thin films separated by few unit cell thin $LaNiO_3$ spacers, grown by pulsed-laser-deposition and investigated by SQUID-mangetometry, magnetotransport and the magneto-optive-Kerr effect. The magnetic anisotropy in Ru-substituted $La_{0.7}Sr_{0.3}MnO_3$ thin films, in combination with light compressive strain of a LSAT substrate, allows to tune the magnetic anisotropy from easy-plain to strong perpendicular-magnetic-anisotropy. $LaNiO_3$, allows for strong FM- or AFM-coupling between the manganite layers depending on spacer thickness. We propose a layer-by-layer type magnetization reversal in the case of strong PMA, introduced by substituting 10% of Mn by Ru, while films with lower substitution of 5% and weaker PMA instead show signs of collective, spin-flop-type transitions.

DS 5.4 Tue 14:45 H3

Multinary compositionally graded, spatially addressable materials libraries by pulsed laser deposition — •Jorrit Marius Bredow, Marius Grundmann, and Holger von Wenckstern — Felix Bloch Institute for Solid State Physics, Leipzig University

The discovery of novel, functional materials is increasingly based on the investigation of multinary materials with large composition spaces. Therefore, combinatorial synthesis and high-throughput characterization methods are preferable for the discovery of functional multicomponent materials. Here, pulsed laser deposition (PLD) from segmented targets allows the synthesis of spatially addressable materials libraries (SA-ML) with continuous compositional gradients[1].

We demonstrate that PLD is a viable method for synthesizing multicomponent SA-ML using n-fold azimuthally segmented targets. We present a roadmap for the fabrication of fivefold segmented targets using MgO, CoO, NiO, CuO, and ZnO, which can be readily applied to different material combinations. Moreover, we compare two approaches to target and deposition process design for PLD of SA-ML. The composition of the SA-ML is determined by high-throughput energy dispersive X-ray spectroscopy confirming the successful synthesis of a fivefold compositionally graded SA-ML by combinatorial PLD. Aditionally, the height distributions and elemental compositions are simulated with the thickness distribution parameters of the binary oxides and the simulation results are compared to the experimental data.

[1] H. von Wenckstern, Z. Zhang, F. Schmidt, J. Lenzner, H. Hochmuth, and M. Grundmann, CrystEngComm, 15, 10020, 2013.

DS 5.5 Tue 15:00 H3

Tri-functionality in a Single Oxide Interface-Based Nanostructure with Reconfigurable Logic-in-Memory Applications — •Soumen Pradhan[1], Kirill Miller[1], Fabian Hartmann[1], Merit Spring[2], Silke Kuhn[1], Victor Lopez-Richard[3], Michael Sing[2], Ralph Claessen[2], and Sven Höfling[1] — [1]Julius-Maximilians-Universität Würzburg, Würzburg-Dresden Cluster of Excellence ct.qmat, Lehrstuhl für Technische Physik, Deutschland — [2]Julius-Maximilians-Universität Würzburg, Würzburg-Dresden Cluster of Excellence ct.qmat, Experimentelle Physik 4, Deutschland — [3]Department of Physics, Federal University of São Carlos, Brazil

We demonstrate transistor (T), memristive (M), and memcapacitive (MC) functionalities in nanowires, based on quasi-two-dimensional electron system in $LaAlO_3/SrTiO_3$ heterostructures depending on the biasing condition at lateral gates. Combining one T and one M, the device can be utilized for short term and long term synaptic plasticity. However, arranging two T in parallel and series with one M, the structures show logic OR and AND gates, respectively. In addition, the devices can memorize the logic output even after grounding the inputs taking advantage of its long term memory. Interestingly, the single structure can be reconfigured between OR and AND logic. Our findings on oxide nanostructures together with logic-in-memory and reconfigurability in logic as well as in functionality open a path towards oxide-based monolithic integrated circuits for brain inspired neuromorphic computing.