DS 39: Thin Oxides and Oxide Layers II (joint session DS/HL)

Time: Thursday 11:00–12:15 Location: CHE 91

DS 39.1 Thu 11:00 CHE 91

Structural, Optical and Electrical Properties of Indium Tungsten Oxide upon High Temperature Annealing — •Dorothee Menzel and Lars Korte — Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Institut für Silizium Photovoltaik, Kekulestrasse 5, 12489 Berlin, Germany

High work function metal oxides, such as tungsten oxide (WOx) have recently been investigated as charge selective p-contacts for silicon heterojunction solar cells: They provide a higher optical transparency, and due to their high work function (WF) it is expected that they can improve the cell's fill factor due to a more efficient carrier separation. However, WOx suffers from a rather poor conductivity. Indium oxide (InOx), on the other hand, has a moderate WF but a much higher conductivity. We vary the ratio of In-to-W oxide by thermal co-evaporation, spanning the full range from pure WOx to pure InOx and search for a tradeoff of high WF and high conductivity. Using in-situ (X-ray and UV) PES and surface photovoltage measurements, we found a pronounced decrease of the WF from 6.3eV for pure WOx down to 4.5eV for 40% of InOx-content in the InWOx mixture. This was accompanied by a decrease of the band bending in the c-Si substrate by 200meV [1]. Further studies focused on the material properties, such as optical, electrical and structural properties of indium tungsten oxide thin films on glass. We will discuss the changes in these properties with changing In-to-W ratio and upon high temperature annealing up to 700°C.

[1] D. Menzel et al., Appl. Phys. Lett., 112, 1-13, 2018.

DS 39.2 Thu 11:15 CHE 91

In-situ observation of sub-unit-cell nonlinear polarization in superlattices of layered oxides — •Johanna Nordlander[1], Marco Campanini[2], Marta D. Rossell[2], Manfred Fiebig[1], and Morgan Trassin[1] — [1]ETH, Zurich, Switzerland — [2]EMPA, Dübendorf, Switzerland

When approaching the 2D-limit of a material, finite size, edge or confinement effects often lead to phenomena that differ from the bulk behavior and promote novel functionalities. In materials with a layered structure, the individual sub-unit-cell layers that form their fundamental building blocks may exhibit a different symmetry, and hence different properties, than those of the parent material. For example, strong nonlinear optical properties may arise from broken inversion symmetry in fractional unit-cells of an otherwise centrosymmetric layered oxide. Here we use in-situ optical second harmonic generation (ISHG) during thin-film deposition to access these unique symmetry properties of sub-unit-cell layers in ultrathin, naturally layered hexagonal manganites. A strong nonlinear polarization directly originating from the inversion-symmetry breaking of individual half-unit-cell layers leads to a striking modulation of ISHG intensity connected to the periodic cancellation and reappearance of a non-centrosymmetric thin-film structure as each half-unit-cell layer is added during thin-film synthesis. We thus reveal the unexpectedly strong optical response of these sub-unit-cell blocks that perfectly cancel in the bulk limit. We furthermore make use of this characteristic dynamic ISHG signature to create oxide superlattices through sub-unit-cell symmetry control.

DS 39.3 Thu 11:30 CHE 91

Ellipsometric study of defect induced magnetism in spinel ferrite thin films — •Vitaly Zviagin[1], Chris Sturm[1], Pablo Esquinazi[1], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1,2] — [1]Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik — [2]Now at: Technische Universität Ilmenau, Institut für Physik

We present the magnetic properties of normal spinel $ZnFe_2O_4$ (ZFO) thin films in dependence on fabrication and annealing temperature as well as atmosphere. The increase in the net magnetic response with decreasing substrate temperature correlates with the increase in cation disorder, evident by an increase in O^{2-}2p-Fe^{3+}_{Td}3d electronic transition amplitude in the dielectric function (DF) spectra.[1] Absorption in the low energy range (∼0.9 eV) is related to an electronic transition between d orbitals of Fe^{2+} and Fe^{3+} cations and shows a strong dependence on fabrication and annealing atmosphere. Comparing the cation distribution in film bulk (optical transitions in the DF) to near-surface region (X-ray absorption), it is found that an inhomogeneous cation distribution leads to a weaker magnetic response in films of inverse configuration, whereas defects in normal spinel are likely to be found at the film surface. The presented results show that it is possible to engineer and to probe the defect distribution in the magnetic spinel ferrite film structure and to tailor their magnetic properties on demand.

[1] V. Zviagin *et al.*, Appl. Phys. Lett. **108**, 13 (2016)

DS 39.4 Thu 11:45 CHE 91

Fast sweep and voltage pulse studies on HfO_2/TiO_2- bilayer resistive switching memories — •Nils Quiring[1], Felix Cüppers[1], Alexander Hardtdegen[1], Susanne Hoffmann-Eifert[1], and Rainer Waser[1,2] — [1]PGI-7, Forschungszentrum Jülich GmbH, Germany — [2]IWE-2, RWTH Aachen University, Germany

Redox-based resistive random access memories (ReRAM) are promising contenders for future information technology applications. Compared to the respective monolayers, bilayer oxide stacks of HfO_2/TiO_2 revealed enhanced switching stability [1]. Yet, the origin of this stability is not fully understood. The inherent variability of properties such as the resistance states, switching voltages and times need further investigation.

In this study, bilayer oxide stacks of HfO_2/TiO_2 sandwiched between a Pt and a Ti electrode are electrically characterized by voltage sweep and pulse measurements. The switching behavior at different voltages, durations and signal waveform geometries with a current limitation is examined. Cells during switching are characterized with respect to cycle to cycle and device to device variability.

[1] A. Hardtdegen et al., " Improved Switching Stability and the Effect of an Internal Series Resistor in HfO_2/TiO_2 Bilayer ReRAM Cells " *IEEE TED*, vol. 65, 8, 2018, pp. 3229-3236.

DS 39.5 Thu 12:00 CHE 91

TiO_x formation during ALD metal oxide growth on Ti for resistive switches — •Ivonne Bente, Stephan Aussen, and Susanne Hoffmann-Eifert — Peter Grünberg Institut, Forschungszentrum Jülich GmbH

We studied the formation of TiO_x at the interface of Ti metal and a metal oxide film, which is grown onto the Ti layer by atomic layer deposition (ALD). For the metal oxide we investigated stoichiometric oxide films (MO) including Al_2O_3, TiO_2 and HfO_2 layers. The 25 nm thick dense Ti films are deposited on thermal oxidized Si wafers in an off-axis sputter tool with a base pressure $< 10^{-10}$ mbar. The Ti films with hexagonal crystal structure exhibit a low surface roughness. The films were transferred under ultra-high vacuum into an ALD plasma system. 2 to 3 nm thick oxide layers are deposited at 250°C using O_2-plasma as the oxygen source and standard metalo-organic precursors for the metal sources. The resulting stacks are investigated by x-ray photoelectron spectroscopy showing different Ti oxidation states (0 to 4^+) and a clear TiO_x thickness dependence on the ALD process. The switching behavior of the resulting stacks is investigated. In addition, complementary resistive switching experiments are performed on equivalent stacks, i.e. $Pt/MO/TiO_x/Ti$. The correlation between the XPS results and the resistive switching characteristics (pristine leakage current, electroforming voltage, etc.) is discussed.