Complex Oxides: Fundamental Properties and Applications Focus Topic
Room Union Station AB - Session OX-TuP
Complex Oxides: Fundamental Properties and Applications Poster Session

OX-TuP-1 Electrical and Structural Properties of p-type Transparent Conducting $La_{2/3}Sr_{1/3}VO_3$ Thin Films Grown Using RF Sputtering Deposition, *D Jung, Y Oh, H So, **Hosun Lee,*** Kyung Hee University, Republic of Korea

The development of efficient p-type transparent conducting oxides (TCOs) remains a global material challenge. Converting oxides from n-type to p-type via acceptor doping is extremely difficult and these materials exhibit low conductivity due to the localized nature of the O 2*p* -derived valence band, which leads to difficulty in introducing shallow acceptors and small hole effective masses. High-quality perovskite oxide (ABO_3) thin film p-n junctions have significant potential for electronic devices with multifunctional properties. The p-type perovskites currently in use are not sufficiently transparent in the visible region. Alloying Sr and La at the A-sites of perovskite $SrVO_3$, i.e. $La_{2/3}Sr_{1/3}VO_3$ (LSVO), can introduce holes at the top of the valence band (VB), resulting in p-type conductivity while maintaining reasonable transparency.

In this work, p-type LSVO thin films were grown on various substrates using RF magnetron co-sputtering deposition with $SrVO_3$ (actually $Sr_2V_2O_7$) and La_2O_3 targets between 400 and 500 °C with a mixed gas of H_2 (35%) and Ar. The generator powers were 60 and 30 W, respectively. Film thicknesses varied between 120 and 150 nm. The growth temperature and sputtering gas ambient were optimized and precisely controlled. The chamber pressure was set at . We used LSAT, $LaAlO_3$, TiO_2/Si, Si, SiO_2/Si as substrates. The structural and morphological properties of LSVO films were studied using grazing angle incidence X-ray diffraction (GIXRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), spectroscopic ellipsometry, and X-ray photoemission spectroscopy (XPS). The electrical properties of all samples were measured using Keithley 4200. Hall effect measurements provided the Hall carrier concentration and Hall mobility as 3.0×10^{20} cm^{-3} and 5.15 $cm^2/(V\cdot s)$, respectively. The resistivity was measured to be 4.1 mΩ·cm. In comparison, Hu et al. reported the resistivity, carrier concentration, and mobilities as 1.15 mΩ·cm, 1.69×10^{21} cm^{-3}, and 3.2 $cm^2/(V\cdot s)$, respectively for LSVO grown by using pulsed layer deposition [1]. GIXRD measurements showed 2Θ = 32.36˚, which arose from (112) plane of tetragonal crystal structure of LSVO films. We discuss the substrate dependence of the electrical and optical properties of LSVO thin films in detail. We plan to develop all perovskite $La_{2/3}Sr_{1/3}VO_3/SrVO_3$ p-n junctions.

[1] L. Hu et al., Adv. Elect. Mater. **4**, 1700476 (2018).

OX-TuP-2 van der Waals Heterostructures of Graphene and β-Ga_2O_3 Nanoflake for Enhancement Mode MESFETs and Logic Applications, ***Janghyuk Kim**, J Kim,* Korea University, Republic of Korea

β-gallium oxide (β-Ga_2O_3) is a promising material for next-generation power electronics due to its wide band gap of ∼4.9 eV and excellent productivity. Interestingly, a single crystalline β-Ga_2O_3 with a monoclinic structure can be exfoliated into ultra-thin flakes along the (100) plane due to its strong in-plane force and weak out-of-plane force. The exfoliated β-Ga_2O_3 flakes can be easily integrated with 2D materials (h-BN, TMDCs) to form van der Waals heterostructures for a down-scaled novel (opto)electronic devices as well. Most of the fabricated β-Ga_2O_3 transistors exhibit n-type characteristics with a negative threshold voltage (V_{th}) due to oxygen vacancy or donor like impurities in β-Ga_2O_3. The negative threshold voltage of n-type β-Ga_2O_3 transistors allows only a depletion mode (D-mode) operation, which limits their implementation in the circuit design. However, an enhancement mode (E-mode) operation, allowing simple circuit designs and fail-safe operation under high voltage conditions, is preferred for power transistors.

We have demonstrated a method to control V_{th} of β-Ga_2O_3 Metal-Semiconductor Field Effect Transistor (MESFET) by using various morphology of van der Waals heterostructure of β-Ga_2O_3 and graphene to achieve an E-mode operation. The junction of β-Ga_2O_3 and graphene forms a Schottky barrier due to the difference of their work functions. In the same β-Ga_2O_3 nanoflake, the β-Ga_2O_3 MESFET with a double gate of the sandwich structure of graphene/β-Ga_2O_3/graphene showed positive V_{th} (E-mode operation) while the bottom gate only MESFET showed negative V_{th} (D-mode operation). Furthermore, a β-Ga_2O_3/graphene van der Waals heterostructure based monolithic Direct Coupled FET Logic (DCFL) inverter was demonstrated by integrating E-mode and D-mode MESFETs on single β-Ga_2O_3 nanoflake and exhibited good inverter characteristics. These results show a great potential of van der Waals heterostructure of β-Ga_2O_3/2D materials on future nanoscale smart power integrated circuit (IC) applications. The details of our results and discussions will be presented .

OX-TuP-3 Structure and Reactitvity of a Magnetite-Terminated Hematite Surface with Oxygen Adatoms Formed by Self-Oxidation, ***Constantin Walenta**, F Xu, W Chen, C O'Connor, C Friend,* Harvard University

The surface composition and structure of reducible oxides, including oxides of Fe, are complex and difficult to control because of the mobility and multiple oxidation states of cations. The magnetite phase of iron oxide is a material with a complex structure and controversial surface terminations that is widely used in heterogeneous catalysis, including the water gas shift reaction and formaldehyde synthesis.

A new, unique termination of oxygen adatoms forms on top of $Fe_3O_4(111)$ film on a α-$Fe_2O_3(0001)$ single crystal in oxygen-deficient environments. By using a combination of chemical and activity analysis (XPS and TPRS), structure analysis (STM and LEED) and DFT calculations, we identify the atomic structure of the as-prepared $Fe_3O_4(111)$ surface and distinguish electronic structure of oxygen adatom and uncovered iron sites. The latter is an active Lewis site for alcohol dissociation at room temperature. Further oxidation of the alkoxy intermediate to the aldehyde occurs at 700 K, and the surface fully recovers after product desorption.

The work establishes a clear understanding of a unique magnetite surface and provides insights in the selective oxidation of alcohols on iron oxide-based catalysts and a rare direct observation of oxygen mobility in iron-oxide based materials.

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