Superstructured Thin Film Chemistry　　Prof. **Masashi Kawasaki** (2001.4~)

【Staff Members】

Prof. Masashi Kawasaki,　Lecturer. Tomoteru Fukumura,　Res. Assoc. Masahiro Kagawa,
Res. Assoc. Yasuo Fujinaga,　Res. Assoc. Keiji Kusaba,　Res. Assoc. Toshiyuki Atou,
Res. Assoc. Akira Ohtomo〈Researcher : 1 / Supporting Staff : 1〉

【Research Activities】

High performance field effect transistors composed of single crystalline ZnO thin film as a channel, polished 10mm-thick substrate as gate-dielectric, and gate electrode attached on the back of the substrate. An electric field as high as 1MV/cm could be applied to mark a mobility as high as 70cm^2/Vs. Hall effect was simultaneously measured for the same device to reveal excellent gate-dielectric/channel interface properties. Residual defect concentration in intrinsic ZnO films could be reduced to a level much better than the world-best bulk single crystal, as revealed by the record-breaking data of exciton radiative recombination lifetime and electron mobility. p-type ZnO could be produced reproducibly by doping nitrogen into high crystallinity ZnO with a repeated temperature modulation technique, where substrate temperature was modulated between 400^{o}C and 1000^{o}C while shining nitrogen radical to the film growing surface. Successful fabrication of ZnO pn light emitting diodes was also demonstrated.

Local magnetism was quantitatively evaluated by nonlinear magneto-optical Kerr (NMOKE) effect at the single interface of ferromagnetic metal and insulator to be a building block of magnetic tunnel junctions. Robust interface structures were proposed, verified by NMOKE, and demonstrated as spin tunnel junctions with a magneto-resistance exceeding 200%. Resistance switching by voltage stress was revealed at Schottky-like junctions composed of insulating correlated electron oxides and metallic electrodes. A possible mechanism based on charge trap at the interface was proposed and nonvolatile memory devices having resistance ration exceeding three orders of magnitude were demonstrated.

1. T. I. Suzuki, A. Ohtomo, A. Tsukazaki, F. Sato, J. Nishii, H. Ohno, M. Kawasaki
"Hall and Field-Effect Mobilities of Electrons Accumulated at a Lattice-Matched ZnO/$ScAlMgO_4$ Heterointerface"
Adv. Mater., 16, 1887-1890 (2004)

2. A Tsukazaki, A. Ohtomo, M. Kawasaki, T. Makino, C. H. Chia, Y. Segawa, H. Koinuma
"Emission from the higher-order excitons in ZnO films grown by laser molecular-beam epitaxy"
Appl. Phys. Lett., 84, 3858-3860 (2004)

3. A. Tsukazaki, A. Ohtomo, T. Onuma, M. Ohtani, T. Makino, M. Sumiya, K. Ohtani, S. F. Chichibu, S. Fuke, Y. Segawa, H. Ohno, H. Koinuma, M. Kawasaki
"Repeated temperature modulation epitaxy for p-type doping and light emitting diode based on ZnO"
Nature Materials, 4, 42-46 (2005)

4. H. Yamada, Y. Ogawa, Y. Ishii, H. Sato, M. Kawasaki, H. Akoh, Y. Tokura
"Engineered Interface of Magnetic Oxides"
Science, 305, 646-648 (2004)

5. A. Sawa, T. Fujii, M. Kawasaki, Y. Tokura
"Hysteretic current-voltage characteristics and resistance switching at a rectifying $Ti/Pr_{0.7}Ca_{0.3}MnO_3$ interface"
Appl. Phys. Lett., 85, 4073-4075 (2004)

【Plan】

We have developed and have been running world-class thin film technology of metal-oxides. The research target of our group is to explore novel functions in nano-scale heterostructures of oxides to realize novel devices with high performances, which would not be accomplished by otherwise materials. Among various oxides, we focus on transparent oxide semiconductors and strongly correlated electron oxides. For the former oxides, we drive high quality ZnO epitaxy technology to make high electron mobility transistors and pn junction light emitting diodes. Interface electro-magnetic properties are to be tuned for the latter oxides so that magnetic tunnel junctions and nonvolatile memories are to be realized.