【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering)

Title of Project : Quantum functionalities and device applications of two-dimensional electron system at oxide interfaces

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Research Area : Applied Physics & Crystal Engineering
Keyword : Heterostructures, Oxide Electronics

【Purpose and Background of the Research】

Oxides provide peculiar properties and functionalities that conventional semiconductors or metals cannot realize. “Oxide Electronics” utilizing these features have advanced for last quarter century to reach quantum-functionality-level propelled by the progress of interface engineering. Most significant recent achievements are superconductivity induced at insulator surfaces by electrostatic field effect [1] and observation of fractional quantum Hall effect in ZnO based hetero-interface [2]. These breakthroughs are recognized world-wide as very visible milestones and are believed to give ripple effects to the progress of oxide electronics of such materials systems as superconductivity, magnetism, ferroelectricity and nonlinear optical effect. In this study, we further advance these studies and aim at discovery of new superconductors, exploration of ferroelectric channel transistors, and realization of novel quantum effect in high-mobility correlated electron systems.

【Research Methods】

Electric double layer formed the interface of solid and electrolyte enables us to accumulate charge carriers over 10^{15}cm^{-2}. Electric double layer transistors (Fig. 1) will be used to convert various insulators into superconductors. This is also used to accumulate electrons on the surfaces of ferroelectric materials to overlay on the spontaneous polarizations. The analysis will explore a novel non-volatile transistor with ferroelectric channel.

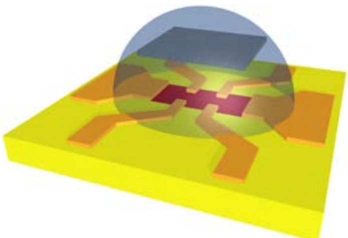

Figure 1 Schematics of electric double layer transistor

Electron mobility at the ZnO/(MgZn)O interface reached 770,000cm^2/Vs that is limited by charged impurity scattering. Further optimization of crystal growth will suppress the scattering providing an arena (Fig. 2) to examine novel quantum effect in clean correlated system that is beyond Wigner crystallization or quantum Hall ferromagnet.

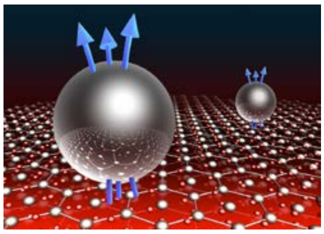

Figure 2 Schematics of fractional quantum Hall effect.

【Expected Research Achievements and Scientific Significance】

Electrostatic doping is a distinct method to search for novel superconductors from conventional ones and is expected to explore new superconductors. Ferroelectric-channel transistors will provide a new principle to form nonvolatile switches. Progress of interface engineering to realize lean correlated system not only unveils new quantum effect but also provides technology platform for improving opto-electric devices of ZnO.

【Publications Relevant to the Project】

[1] A. Tsukazaki, et. al., "Observation of the fractional quantum Hall effect in an oxide", *Nature Materials,* **9**, 889-893 (2010).
[2] K. Ueno, et. al. "Discovery of superconductivity in $KTaO_3$ by electrostatic carrier doping", *Nature Nanotechnology,* **6**, 408-412 (2011).

【Term of Project】 FY2012-2016

【Budget Allocation】 167,800 Thousand Yen

【Homepage Address and Other Contact Information】

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