Professor M. Kawasaki -- The First Observation of the Fractional Quantum Hall Effect in high quality Oxide heterointerface --

- Toward the elucidation of new electron's quantum behavior –

As part of PRESTO (Precursory Research for Embryonic Science and Technology) of JST Basic Research Programs, a research group led by Dr. Atsushi Tsukazaki, who is now a Lecturer at Quantum-Phase Electronic Center of the University of Tokyo, and by Professor Masashi Kawasaki at WPI Advanced Institute for Materials Research in Tohoku University has demonstrated for the first time the fractional quantum Hall effect in the electron gas confined at the oxide heterointerface. This observation is an important step toward the understanding of the fundamental electron interactions in low dimensional oxide systems and became possible due to the progress in the fabrication of extremely pure oxide interfaces.

The work is based on zinc oxide (ZnO) material, which recently attracted the attention as a low cost, harmless and transparent semiconductor. The electron gas is confined at the interface between thin layers of MgZnO and ZnO and can move freely within the plane. The fabrication of pure interface was challenging, since the control of interface smoothness, impurity concentration as well as crystal defects are much more difficult in ZnO than in III-V compound semiconductors, which hold the current record in electron mobility.

Yet the group has mastered the growth of thin films and fabricated a smooth interface of high purity using molecular beam epitaxial technique. The electron mobility has been considerably increased and is now ten times larger than in the existing oxide materials. This breakthrough was essential to succeed in observing the fractional quantum Hall effect, which was seen in only few materials including GaAs and graphene.

The observed phenomenon is one of macroscopic quantum states of electrons such as superconductivity or superfluidity. It will contribute to the understanding of electron transport in oxide materials and will help to develop new materials. Moreover, the progress in control of ZnO quality is important for possible applications and paves the way to employ environment friendly material for it. ZnO becomes a candidate material to fabricate ultraviolet light emitting devices, which will replace blue light emitting devices. Also the application of ZnO for transparent transistor is conceivable.

The research was conducted in collaboration with ROHM Co., Ltd., Research Institute of Electrical Communication, Tohoku University and Graduate School of Engineering, Tokyo Institute of Technology. The result is published as advance online publication in Nature Materials, British scientific journal, on October 17, 2010. The paper's title is "Observation of the fractional quantum Hall effect in an oxide."

[Contact for questions about the research]
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