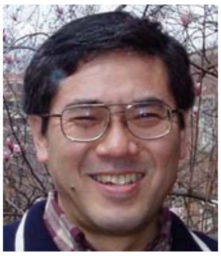

Title of Project : Electronic Phase Control of Matter Using Ultra-high Electric Field at Electrochemical Interfaces

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Research Area : Mathematical and physical sciences

Keyword : Superconductivity/Density wave system, Molecular solid/Organic conductor

【Purpose and Background of the Research】

Field Effect Transistor (FET), in which the carrier density is changed by electrostatic charge accumulation in capacitors structures, is one of the key devices for the modern IT society. To induce electronic phase transition such as superconductivity by electrostatic charge accumulation in FET structures has attracted considerable interest of solid state physicists for this half a century since the first invention of Si-MOS-FET. However, despite its simple principle, the conventional FET structure has been believed to be practically incapable of accumulating enough charge density for inducing electronic phase transitions. taking this situation into account, we introduce electrochemical solid-liquid interfaces, where one is able to achieve extremely high density carrier accumulation. The purpose of this research is to establish a novel technique to control the electronic states in variety of materials by this electrochemical transistor, which we call electric double layer transistor (EDLT), and to offer an interdisciplinary materials science in which we are able to realize new states of matter which is inaccessible by conventional chemistry.

【Research Methods】

(1) Increase of carrier density reached by electrostatic method

For generalizing electric field induced superconductivity, the increase of carrier density is of crucial importance. For this purpose, we employ ionic liquid instead of conventional polymer electrolyte. Since it is reported that the capacitance of EDL for ionic liquid is larger than that for polymer electrolyte. Using this, we anticipate the maximum carrier density up to $8x10^{14}cm^{-2}$. This work should be carried out in collaboration with outside researchers.

(2) Search for electric field induced superconductivity in variety of materials

A central issue of this project is to realize electric field induced superconductivity in other systems than $SrTiO_3$. For this purpose, we focus on layered materials. Since the carrier transport occurs at the surface of solids, the preparation of atomically flat surface is of critical importance. T The layered materials is of highly advantageous because the micro cleavage method like that in graphene device is available.

(3) In-situ probe of electrochemical reaction

Expanding the concept of EDLT, the in-situ characterization of electrochemical reaction will be performed by means of resistivity and magnetic susceptibility measurements at low temperature to search for new electronic phases as nonequilibrium states.

【Expected Research Achievements and Scientific Significance】

The goal of this project is to establish this technique as a tool for searching for new states of matter which can not be accessed by conventional chemical syntheses. When this goal is reached, variety of new states which is only stabilized under electric field could be discovered, involving hopefully new high temperature superconductors. The biggest impact after ten or more years is the development of new materials science with rich variation of electronic functions, hopefully high Tc superconductivity, through nonequilibrium states.

【Publications Relevant to the Project】

H. Shimotani, H. Asanuma, A. Tsukazaki, A. Ohtomo,M. Kawasaki, and Y. Iwasa, "Insulator-to-metal transition in ZnO by electric double layer gating" , *Appl. Phys. Lett.* 91, 082106 (2007).

K. Ueno, S. Nakamura, H. Shimotani, A. Ohtomo, N. Kimura, T. Nojima, H. Aoki, Y. Iwasa & M. Kawasaki, "Electric field induced superconductivity in an insulator", *Nature Materials* 7, 85 (2008)

【Term of Project】 FY2009-2013

【Budget Allocation】 168,500 Thousand Yen

【Homepage Address and Other Contact Information】

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