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

Title of Project : Molecular Conductors as Ultimate π-electron System

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Research Area : Mathematical and physical sciences

Keyword : Molecular solid/Organic conductor, Electric and magnetic properties, Strongly correlated electron system, Organic electronic material/device

【Purpose and Background of the Research】

Electrons in solid state exhibit a variety of electric and magnetic properties, depending on orbital where electrons are accommodated. In molecular solids, π-electron systems formed by p and/or d orbitals have the following characteristics and have triggered extensive researches:

1) Simple and clear electronic structures
2) Low-dimensional and strongly correlated nature
3) Colossal responses to external stimuli (magnetic field, pressure, temperature, light…etc.)
4) Light and soft
5) A variety of chemical modifications and molecular degrees of freedom
6) Stoichiometrically clean system with small defect can be obtained by low-energy wet process

In this project, we will quest for ultimate π-electron system in molecular conductors and pursue possibilities of π-electron functions.

【Research Methods】

Main topics are as follows:

1. Dual function (itinerant/localized) π-electron system

We have found a dual function π-electron system where "one" kind of π-molecule plays "two" contrastive roles (metallic conduction and paramagnetism with AF interactions). The ground state associated with "Kondo effect"-like behavior will be clarified by various methods including ESR and cyclotron resonance.

2. Strongly correlated π-electron FET (Field Effect Transistor)

We have succeeded in the fabrication of molecular Mott FET by using thin single crystal and obtained high device mobility. Using this, we will reveal mechanism of band-filling controlled Mott transition, as well as enhancement of device performance.

3. Dirac π-electron system

Based on our finding of the first multilayer massless Dirac fermion system, we will investigate effects of carrier doping and tilted Dirac cones.

4. π-electron system under extremely high pressure

Using diamond anvil cell technique, we explore new electronic states of π-electron system under extremely high pressure up to 40 GPa.

【Expected Research Achievements and Scientific Significance】

We will enhance performance of π-electron materials up to the ultimate, using our original compounds and methods. We also develop novel electric/magnetic properties and novel materials based on the collaboration between physicists and chemists. This project will open new interdisciplinary field of materials science, which constructs basis of molecular electronics and devices.

【Publications Relevant to the Project】

・ Y. Kosaka, H. M. Yamamoto, A. Nakao, M. Tamura, and R. Kato, "Coexistence of Conducting and Magnetic Electrons Based on Molecular π-Electrons in the Supramolecular Conductor (Me-3,5-DIP)[Ni(dmit)$_2$]$_2$", *J. Am. Chem. Soc.*, **129**, 3054-3055 (2007).

・ N. Tajima, S. Sugawara, R. Kato, Y. Nishio, and K. Kajita, "Effect of the Zero-Mode Landau Level on Interlayer Magnetoresistance in Multilayer Massless Dirac Fermion Systems", *Phys. Rev. Lett.* **102**, 176403 (2009).

・ Y. Kawasugi, H. M. Yamamoto, N. Tajima, T. Fukunaga, K. Tsukagoshi, and R. Kato, "Field-Induced Carrier Delocalization in the Strain-Induced Mott Insulating State of an Organic Superconductor", *Phys. Rev. Lett.*, **103**, 116801 (2009).

【Term of Project】 FY2010-2014

【Budget Allocation】 167,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.riken.jp/lab-www/molecule/