Development of superconducting devices based on light elements

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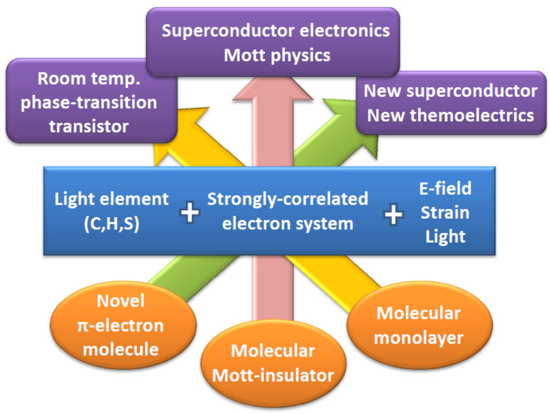
We have been developing superconducting devices based on organic molecules. Organic molecules are attracting recent attention as new ingredients for electronic circuits not only because of being light-weight and flexible but also because of their stable supply from fossil oils. Among those, organic Mott-insulators are quite interesting because they show various types of phase transitions including superconducting transition, originating from the strong correlation between electrons. Thus they are potentially able to switch their electronic phases upon external stimuli. In addition to the above interest as electronic devices, a study on the physics of strongly correlated electron systems (so-called Mott physics) through the devices' operation is also of great significance, as their superconducting mechanism is relevant to that of high-T_c cuprate superconductors.

Specifically, ON/OFF switching of superconducting field-effect-transistor (FET) based on κ-type BEDT-TTF (BEDT-TTF = bis(ethylenedithio)tetrathiafulvalene) or A_3C_{60} (A = K, Cs, Rb) will be controlled either by electric field, mechanical strain, and/or light-irradiation. Since molecular materials have smaller number of carriers than inorganics at a given interface, an extent of band-filling control becomes larger [1]. They also retain flexibility even at low temperature, which allows wide range of band-width control by strain [2]. In addition, superconductivity of molecular materials can be controlled by light when they are combined with photo responsive molecules at a device interface [3]. These devices may applicable to following utilizations: (1) Quantum computing, single photon sensor, or strain sensor using superconductivity. (2) Exploration of new materials for superconductivity or thermoelectric properties, by changing band-filling through electric-field-effect. Strongly correlated materials are especially interesting because they show steep slope in the density of state due to pseudo gap formation. (3) Phase transition transistor that works at room temperature. Molecular monolayer technology allows both interfacial chemical doping and high ON/OFF ratio in such a device.

In addition, arbitral control over band-filling and band-width helps us to investigate entire phase diagram of organic Mott-insulator.



Concept of this study

References

[1] H. M. Yamamoto, et al; Nature Commun. **4**, 2379 (2013).

[2] M. Suda, et al; Adv. Mater., **26**, 3490 (2014).

[3] M. Suda, et al; Science, **347**, 743 (2015).

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