Field-effect on the strain-induced Mott insulating state of an organic superconductor

Yoshitaka Kawasugi[1,2], Hiroshi M. Yamamoto[2], Naoya Tajima[2], Takeo Fukunaga[2], Kazuhito Tsukagoshi[3], and Reizo Kato[1,2]

[1]*Department of Science and Engineering, Saitama University, Japan.*

[2]*Condensed Molecular Materials Lab., RIKEN, Japan.*

[3]*MANA, NIMS, Japan.*

Email: kawasugi@riken.jp, yhiroshi@riken.jp

Electrostatic carrier doping using the field-effect transistor (FET) configuration enables the precise band-filling control without impurity doping. Recently, we succeeded in the fabrication of FET structure with a thin single crystal of molecular conductor [1]. We will report the field-effect on the strain-induced Mott insulating state of κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br, in which the charge gap continuously collapses.

A crystal adhered to a SiO_2/Si substrate (Figure) behaves as a semiconductor down to the lowest temperature, while the one on a polymer-based flexible substrate becomes a superconductor similarly to typical bulk crystals. The semiconducting state on SiO_2/Si can be explained by the biaxial negative pressure caused by the difference in thermal contraction between the crystals and SiO_2/Si substrates. According to the pressure-temperature phase diagram for this material group, the semiconducting state is considered to be the Mott insulating state.

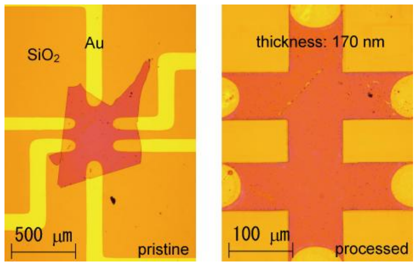

Figure: Optical images of a κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br single crystal on a SiO_2/Si substrate in pristine (left) and processed forms (right). Pulsed laser light was used to shape the crystal. The gate voltage is applied normal to this image in order to induce charge carriers at the interface between the crystal and substrate.

When we apply a *positive* gate voltage to the insulating sample, the activation energy reversibly changes from 25 to 0.3 meV. In the case of conventional FETs, this phenomenon is understood as the result of the raise of chemical potential by *electron* injection. However, the gate voltage dependence of the Hall coefficient indicates that *hole* carriers are excited by the positive gate voltage. This behavior suggests the collapse of the Mott-Hubbard gap, which is peculiar to the Mott FET.

*This work was supported by Grants-in-Aid for Scientific Research (Nos. 16GS0219, 20681014) from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Reference:

[1] Y. Kawasugi *et al.*, Appl. Phys. Lett. **92** (2008) 043508.