Big possibilities of small crystals (II)
-Electronic devices based on molecular conductors-

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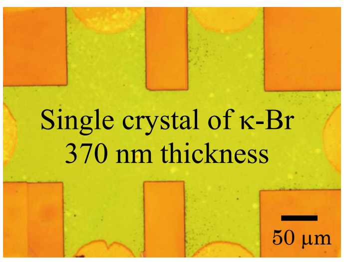
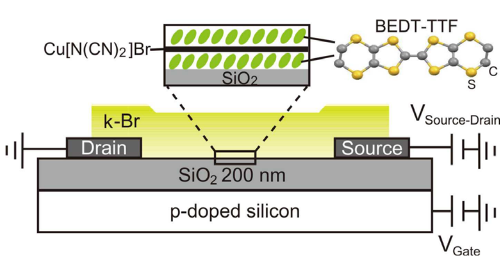
Molecular conductors form a class of conducting materials including metallic, semiconducting, and superconducting ones. The electron correlation, or the Coulomb repulsion between conduction carriers, often plays an important role in determining the conduction properties of the molecular conductors, especially when the superconductivity is concerned. The electron correlation is also responsible for the high-T_C superconductivity in cuprates. Therefore, it is of an intense interest to control the electron correlation by FET (field effect transistor) structure. Since the FET device allows the control of carrier density in the material, which alters the strength of Coulomb repulsion, it is expected that an insulator can be turned into a superconductor under certain device condition. In this prospect, we are interested in fabricating a FET device based on molecular conductors with strong electron correlation.

In order to have a good extent of field effect, it is necessary to place a very thin single crystal on a substrate, because the number of carriers that can be induced by the field effect is quite limited compared to that of the intrinsic carriers. We have recently succeeded in preparing such thin-layer device with a molecular conductor κ-$(BEDT\text{-}TTF)_2Cu[N(CN)_2]Br$, or κ-Br. κ-Br is known to be superconducting at 11 K under ambient pressure, but becomes an insulator on a silicon substrate. In this insulating state, we have observed clear n-type field effect behavior of the device. The field effect mobility, or the measure of the switching speed of a transistor, of this device has reached 94 $cm^2V^{-1}s^{-1}$. This is the highest mobility observed for organic FETs and this value is comparable to that of polycrystalline silicon devices. Pursuit of the insulator-superconductor transition is now in progress. The author will discuss the details of this device and also present a memory device behavior of an anion radical salt, $(DMe\text{-}DCNQI)_2Ag$.

Recent progresses of organic electronics such as OLED (organic light emitting diode), OFET (organic field effect transistor), and OPV (organic photovoltaics) have been quite rapid but now reaching their limits, and new materials and new guiding principles for the devices in the next generation are being required. Our results provoke possibilities of replacing neutral molecules in the present organic devices with organic charge-transfer salts, *i.e.* molecular conductors to improve the device efficiency.

(BEDT-TTF = bis(ethylenedithio)tetrathiafulvalene, DMe-DCNQI = 2,5-dimethyl-*N,N'*-dicyanoquinodiimine)





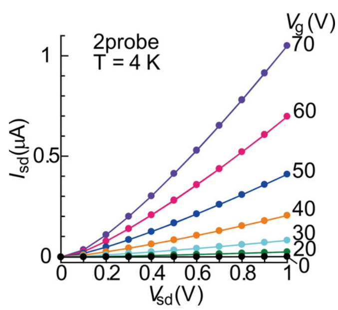


Fig 1 (left): Microscope image of the κ-Br FET device.

Fig 2 (middle): Schematic cross section of the κ-Br FET.

Fig 3 (right): I-V characteristics of the device under various gate voltages. As the gate voltage was increased, the source-drain current (I_{sd}) increased dramatically.