Crystal Growth and Conduction Property Measurement of Micro/Nano-size Molecular Conductors on SiO_2/Si Substrates

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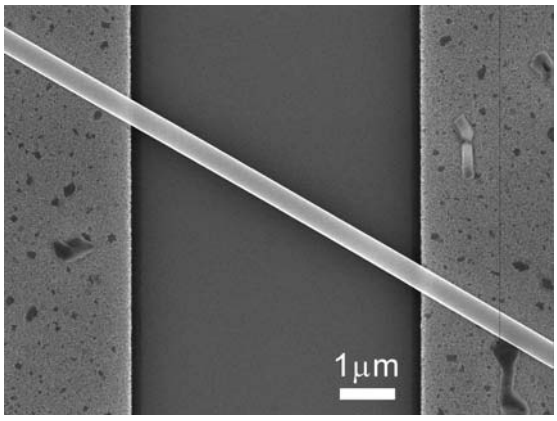
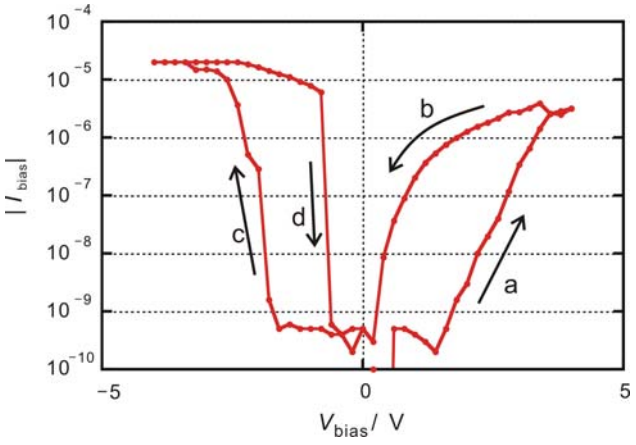
We have recently developed two methods to grow moicro/nano-size crystalline molecular conductors from electrodes deposited on SiO_2/Si substrates. The one is to grow the crystals by electrochemical reaction, and the other is to grow the crystals by chemical reaction between the Ag (or Cu) electrode and acceptor molecules. We have measured the conduction behaviors of these tiny crystalline molecular conductors, and compared them with those for bulk crystals. Here we report the conduction properties of micro/nano-size α-(BEDT-TTF)$_2$I$_3$, (DMe-DCNQI)$_2$Ag, (DMe-DCNQI-*d7*)$_2$Cu, (EDT-TTF)$_4$BrI$_2$(TIE)$_5$, and so on.

For example, micro-size α-(BEDT-TTF)$_2$I$_3$, which shows a metal-insulator (M-I) transition at 135 K in bulk phase, on SiO_2/Si substrate exhibited an M-I transition at 150 K. The difference in the transition temperature can be attributed to the crystal size and/or negative pressure effect based on the small thermal expansion coefficient of the substrate. This crystal also worked as an n-type field effect transistor at 90 K.

Another example is on the M-I transition of (DMe-DCNQI-*d7*)$_2$Cu. This salt is known to show a sharp M-I transition at 80 K, but the sample of 100 nm thickness exhibited no transition or anomaly and kept metallic behavior down to 4 K.

Rectifying behavior of (DMe-DCNQI)$_2$Ag was achieved by exposing half side of the crystal to UV/vis light. Moreover, when it was embedded between Au and Ag electrodes, it showed bistable resistance behavior at room temperature in air as shown in the right figure below. This behavior is suitable for application use in electric circuits as resistive random access memory (RRAM).





Left figure: SEM image of the needle crystal of (DMe-DCNQI)$_2$Ag embedded between two Ag/Au electrodes.

Right figure: I-V characteristics of (DMe-DCNQI)$_2$Ag attached to Ag/Au and Au electrodes at room temperature. The current is drawn in absolute value. The characters from a to d indicates the scan sequence of which rate is 0.4 V/sec.