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# Charge carrier injection into BEDT-TTF charge transfer salt single crystals using ion-gel-gated transistors

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Ion-gel-gated transistors attract attention as a unique technique for charge carrier injection [1]. Large capacitance due to the electric double layer formation enables injection of large amount of carriers reaching $10^{15}$ cm$^{-2}$ at the interface. This technique will be beneficial as a long-desired tool for the band filling control of organic charge transfer salts, however, applications to organic charge transfer salts are limited until now. We fabricated ion-gel-gated transistors of a charge-ordered insulator $\alpha$-(BEDT-TTF)$_2$IBr$_2$ and measured the characteristics at low temperature. Ionic liquid EMIM-TSFI was gelated by dissolving 15 wt% PMMA. Source and drain electrodes were attached to a single crystal with gold or carbon paste. The crystal surface was set in contact with the ion gel injected along a trench cut on a Teflon substrate. At the bottom of the trench, a gold wire was set as a gate electrode. Temperature dependence of the drain current was measured under gate voltages up to 5 V and drain voltages of 10-50 mV applied at 240 K. Below 200 K, we found a reversible n-type enhancement of the drain current. The field-effect gain, or on-off ratio, was 2 to 5 depending on samples. The activation energy of the drain current was reduced from 0.15 eV to 0.13 eV by the application of gate voltages, however, the semiconducting behavior remained. The n-type behavior agrees with the negative Seebeck coefficient observed below 200 K. Considering that charges up to 0.25 per BEDT-TTF molecule were injected by the ion-gel gating, this result indicates that the charge ordered state of $\alpha$-(BEDT-TTF)$_2$IBr$_2$ is robust against the band filling control.

[1] Y. Ando, H. Ito, S. Watanabe, S. Kuroda, J. Phys. Soc. Jpn. **81**, 114724 (2012).