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Light-induced superconductivity in an organic Mott insulator induced by light-driven carrier doping

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Recently, electric-double-layers (EDL) of ionic liquids with huge capacitance have been employed in superconducting field-effect transistors as a nano-gap capacitor. However, due to the freezing of the ionic motions below ~200 K, modulations of the carrier density so far have been limited to the high-temperature regime. In this study, we fabricated novel photo-active superconducting devices by laminating a single crystal of κ-(BEDT-TTF)$_2$Cu[N(CN)$_t$]Br on the substrates coated with self-assembled monolayer of spyropiran-derivatives (SP-SAM). The initial resistances for the devices showed Mott insulator phase in the resistance measurements. After UV irradiation, however, superconducting transition was clearly observed. This photo-induced superconducting phase remained even after the irradiation was stopped. The resistance recovered to nearly the initial value by visible light irradiation, showing a reversible switching capability. From our previous measurements, κ-Br is known to evoke superconductivity by electrostatic carrier doping. The above reversible switching of superconductivity should also be due to a carrier doping by the formation of EDL at the interface. Indeed, spyropirans can switch between a non-ionic isomer and a zwitterionic isomer when triggered by light-irradiation with different wavelengths, resulting in a significant change in the electric dipole moment. Reversible changes in dipole moment of SP-SAM produced two distinct electric fields between the κ-Br and the substrates that created electrostatically doped carriers. Thus, superconductivity could be switched by photo-irradiation by photo-induced EDL formation. This result opens new possibilities for the novel electronics utilizing a photo-active electric double layer which can modulate electric-fields by light irradiation.

Biography

Masayuki Suda is an Assistant Professor at Research Center of Integrative Molecular Systems, Institute for Molecular Science, Japan. He has his expertise in "Photo-functional magnetic and conducting molecular devices". He developed new photo-control method for organic-inorganic interface dipoles which can modulate the magnetic or conducting properties at the device interfaces. He recently applied this method to the field-effect transistor devices based on organic Mott insulators and realized first light-induced superconductivity in organic materials. In recognition of this achievement, he won PCCP award from Royal Society of Chemistry in 2016

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