A Novel Optoelectronic Function in an Organic Conductor: Memory Effect of Photoswitching Behavior Controlled by Pulsed Electric Fields and Photoirradiation

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Switching phenomena of properties in condensed matters have aroused a great deal of interest because of its potential use in advanced functional devices. Organic conductors have been intensively investigated as one of the most advanced materials for the exploration of materials which show switching phenomena. In this paper, we report that electrical conductivity switching is induced by photoirradiation in a single crystal of α-(BEDT-TTF)$_2$I$_3$, and that the conductivity can be controlled using photoirradiation and pulsed electric fields. α-(BEDT-TTF)$_2$I$_3$ shows a metallic high conductivity at room temperature, and undergoes a metal–insulator phase transition at $T_{M–I}$ = 135 K. We studied photoresponse in the presence of electric fields at temperatures below the $T_{M–I}$. Time-resolved measurements of the current following the photoirradiation were performed using a nanosecond laser pulse at the wavelength of 532 nm in synchronization with the application of pulsed voltage [1-3]. Without photoirradiation, a low conductivity (LC) state due to the insulating phase of the crystal was observed. With photoirradiation, the photoinduced conductivity switching from the LC state to a high conductivity (HC) state was observed. The time profile of current showed a persistent profile as long as the voltage was being applied. The current showed a bistability with respect to both the voltage and the light intensity. After the photoinduced switching, the HC state was repeatedly recovered by applying pulsed voltages without further photoirradiation even after the current had been reduced to zero. This result indicates a memory effect of the photoinduced conductivity switching. The recovery to the HC state could be controlled by adjusting the temporal width of voltage pulse, voltage height, and/or photoirradiation intensity. Joule heating effect was not significant as the origin of the memory effect [4]. Such controllability of the photoswitching is unprecedented and can be distinct advantages over conventional switching devices.

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