Ultrafast Charge Dynamics in Organic One-Dimensional Mott Insulators

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Recently, the controls of the Mott-insulator states by photocarrier doping have been extensively investigated in one-dimensional (1D) half-filled correlated electron systems, such as transition-metal complexes and organic molecular compounds. One of the most dramatic examples is photoinduced insulator to metal transition in bromine-bridged Ni-chain (Ni-Br) compound investigated by femtosecond (fs) pump-probe (PP) reflection spectroscopy [1]. When the Mott insulator state of the Ni chain was excited by a 130-fs laser pulse, the reflection band of charge transfer transition at ~1.3 eV collapsed and the Drude-like high reflection band emerged in the IR region, suggesting the formation of a metallic state.

Generally speaking, electron-lattice (e-l) interaction will play a significant role on the charge dynamics in 1D Mott insulators. Thus, in order to understand the charge dynamics in photoexcited 1D Mott insulators, it is important to clarify the effects of the e-l interaction. In the present study, we have performed the comparative studies of the fs PP reflection spectroscopy on the 1D Mott insulators of organic charge transfer compounds, (BEDT-TTF)(F_2TCNQ), Rb-TCNQ, and K-TCNQ with different magnitudes of the e-l interaction [2].

The results revealed that in (BEDT-TTF)(F_2TCNQ) with small e-l interaction, the Drude response was observed even by a small excitation photon density (0.003 ph./site) [3], while K-TCNQ with strong e-l interaction, a mid-gap absorption due to small polarons was clearly observed [4]. In Rb-TCNQ with the intermediate e-l interaction, the Drude response was not observed but photocarriers were weakly localized. The decay time of photocarriers was evaluated to be 0.2 ps for (BEDT-TTF)(F_2TCNQ), 0.8 ps for Rb-TCNQ, and 1.3 ps for K-TCNQ. These results can be well explained by taking into account the magnitudes of the e-l interactions and the degree of the localization of photocarriers.

References

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