Terahertz Spectroscopy Study of CdSSe Nanobelts

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Terahertz (THz) wave refers to electromagnetic radiation in the frequency interval from 0.1 to 10 THz. THz time-domain spectroscopy (THz-TDS) is a powerful technique to study materials properties such as complex dielectric response and conductivity in the far-infrared spectral region, with the advantages of high signal-to-noise ratio, noncontact optical probe, and measuring the amplitude and phase of electric field simultaneously thus no requirement for Kramers-Kronig transformation. The optical pump-THz probe (OPTP) spectroscopy has recently emerged as a powerful technique to study the carrier dynamics of materials. In OPTP, the photon energy of THz probe is in the range of meV (1 THz = 4.1 meV), naturally matching the energy scale of elementary excitation in solids (i.e., excitons, phonons). THz spectroscopy shows its advantage for study the conductivity of nanostructures, because of no requirement for electrical contacts.

One-dimensional (1-D) and quasi 1-D semiconductor nanostructures have attracted much attention in recent years. In particular, CdSSe nanowires (NWs) and nanobelts (NBs) have received much attention and are considered as promising materials for applications in the area of photonics, photodetectors, photovoltaics, and photocatalysis. To optimize the performance of these electronic and optoelectronic devices, a comprehensive understanding of the transient electrical and optical response, carrier relaxation and diffusion as well as the size- or surface-dependent effect on the carrier dynamics is essential. However, there are few investigations on the transient photoconductivity of 1-D CdSSe nanostructures or any other nanobelt materials. It is extremely challenging to measure the conductivity of semiconductor nanostructures due to the inherent difficulties with the fabrication of Ohmic contacts on nanostructures with the traditional techniques. However, the transient complex-valued and frequency-dependent photoconductivity of nanostructures can be easily probed by the THz spectroscopy. In this talk, I will present the THz spectroscopy study of carrier dynamics and transient photoconductivity of CdSSe NBs. In equilibrium condition (without photoexcitation), the carrier dynamics is mainly affected by the surface depletion region. However, upon photoexcitation, the surface effect is masked by the high photocarrier concentration. In this case, the carrier dynamics is mainly determined by the carrier localization due to composition disorder. The contributions to the carrier mobility from different types of scattering or interaction (surface depletion region scattering, alloy scattering, and optical phonon scattering) are also studied. Our results help to elucidate fundamental physical processes of electron transport in the ternary alloy nanobelts, and are useful for the device application of CdS_xSe_{1-x} nanobelts.

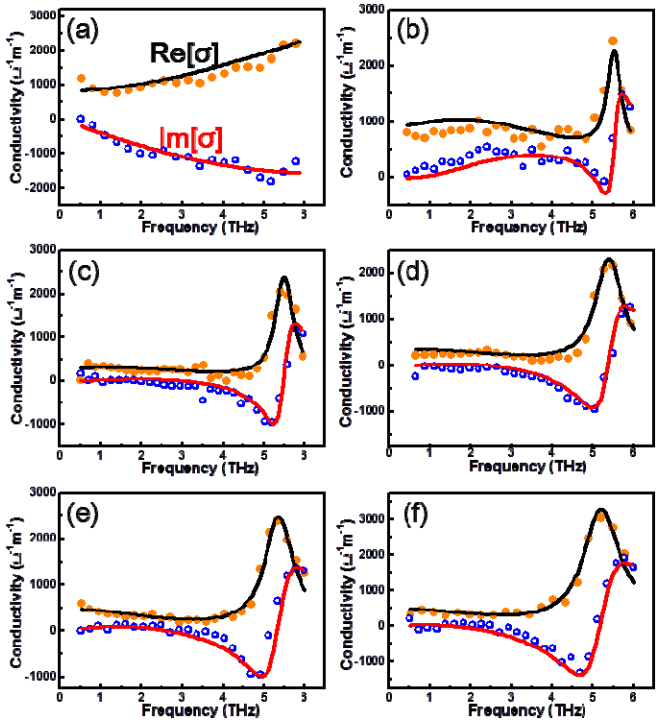

Fig. 1. frequency-dependent complex conductivities of six samples with different compositon (x = (a) 1, (b) 0.87, (c) 0.75, (d) 0.65, (e) 0.29 and (f) 0, respectively) and solid lines show the fitted data by Drude-Smith model.

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