Large HgTe nanocrystals for THz technology

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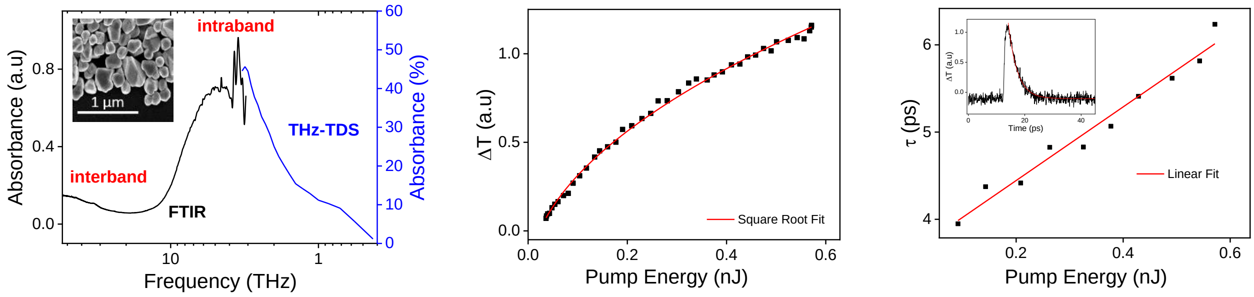
Whereas only few materials can address interband or intersublevel absorption in the THz range, some absorption features at high THz frequencies have been recently demonstrated in large HgTe nanocrystals (of typical size 200 nm) [1]. Indeed, important progress has been obtained on colloidal growth, resulting in a tunable long wavelength absorption peak at THz frequencies. Such HgTe nanocrystals are very attractive for applications since they are low cost and extremely easy to produce [2]. To exploit their potential for THz technology, it is crucial to investigate their optical properties in the full THz frequency range and to get knowledge on the relaxation dynamics of non-equilibrium carriers in these nanocrystals.

Here we process large HgTe nanocrystals (~100 nm size), using colloidal synthesis [1] and study their optical properties in the THz spectral range. We show that their absorbance spectrum, reported in Fig. 1.a., exhibits a broad absorption at high energy (>30 THz) arising from interband transitions and a strong resonance centered at ~4 THz [3]. Using an effective mass model of doped HgTe nanocrystals demonstrate that the observed resonance at ~4 THz is well described by single carrier intraband transitions. We further study the properties of the HgTe nanocrystals at THz frequencies under optical excitation at 800 nm wavelength using an optical pump-THz probe experiment. The differential transmission amplitude ΔT of the THz probe pulse with and without optical pumping follows a root-square law with the incident pump energy (see Fig. 1.b). The dynamics of ΔT, (see insert of Fig. 1.c), as a function of the pump-probe delay are well fitted by a mono-exponential decay law. We extract hot carrier relaxation time τ that increases from 4 ps up to 6 ps as the pump energy is increased (see Fig. 1.c).



Figures : (a) Absorbance spectra of HgTe nanocrystals at room temperature. High frequency spectrum has been obtained using FTIR measurements while low frequency spectrum has been measured using THz-TDS. Insert: SEM Image of large HgTe nanocrystals. (b) Differential transmission amplitude ΔT as a function of the incident pump energy. (c) Extracted carrier relaxation time τ as a function of the incident pump energy. Insert: Measured differential THz transmission ΔT as a function of the pump-probe delay. The red line represents mono-exponential decay law.

Our study uniquely reveals a large THz absorption relying on single carrier intraband transition in HgTe nanocrystals of ~100 nm size. We also demonstrate a hot carrier relaxation time in the range of few ps, demonstrating the great potential of these large HgTe nanocrystals for the development of advanced THz optoelectronic devices.

References:

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