

# Charge Transfer Dynamics between Colloidal Nanocrystals and Graphene

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**Abstract:** We apply time-resolved photoluminescence and ultrafast transient absorption spectroscopy to investigate the electron transfer between PbS nanocrystals and graphene. We find sub-ns decay times and we find strong evidence for a major contribution of charge transfer.

**OCIS codes:** (300.6470) Spectroscopy; (040.5350) Detectors.

Charge carriers in graphene exhibit a high mobility and graphene shows record thermal conductivity and stiffness, it is the thinnest and most robust material known today [1]. Furthermore, graphene is highly transparent over a broad spectral range [2], making graphene a candidate as fundamental electrode material for solar cells.

Semiconductor nanocrystals are a promising light-absorbing material. The optical response of the nanocrystals is tunable and different bandgaps can be combined in tandem-cell devices [3,4]. There are further ways to prevent the thermalization loss produced from the absorption of high-energy photons above the bandgap. The absorption of a single photon can generate multiple excitons with high efficiencies [5].

Efforts using nanocrystal-graphene combinations for photodetectors demonstrate that this combination can result in carrier separation, making possible device configurations simpler [6]. We use ultrafast time-resolved photoluminescence and transient absorption spectroscopy to investigate the interaction between photoexcited nanocrystals and graphene.

Epitaxial graphenes were transferred on glass by using an established route [7]. Parts of the samples were covered with PbS nanocrystals dots by dipcoating. Different ligand environments were tested. Transient absorption was measured using a femtosecond regenerative amplifier with an optical parametric amplifier (Spectra-Physics). This source was coupled to a supercontinuum transient absorption spectrometer (Ultrafast Systems). For time-resolved photoluminescence a frequency-doubled mode Ti:sapphire laser (Coherent) was used as excitation source. Spatial resolution was achieved using a custom-built mirror scanning microscope (PicoHarp) and time-resolved spectra were recorded using a streak camera (Hamamatsu).

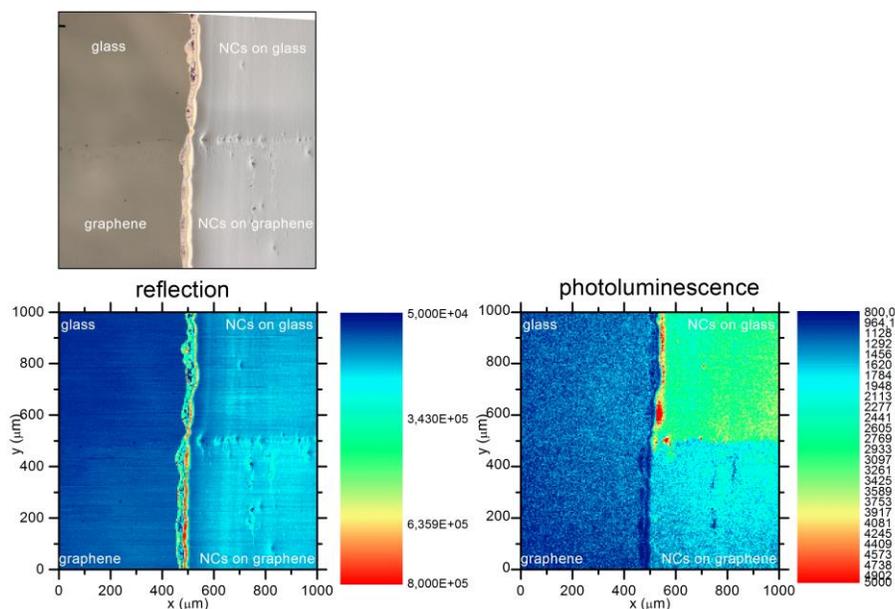


Fig 1. Microscope of the image of an exemplary sample (top) and reflected laser light and photoluminescence map (bottom)

Figure 1 displays the layout of the sample. The reflected laser light is shown in the bottom part of the figure. The nanocrystal film shows no macroscopic differences between graphene and glass as substrate. However, the photoluminescence is significantly quenched. Time-resolved measurements reveal a fast, sub-ns component of the photoluminescence decay on graphene.

This is further studies with transient absorption experiments. Figure 2 displays the time evolution of the fundamental exciton bleach after photoexcitation.

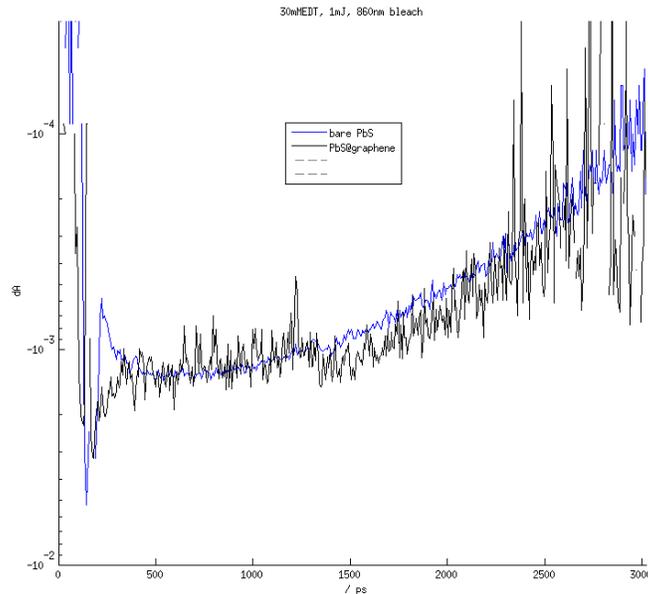


Fig. 2: Transient of the excitonic bleach.

After relaxation of hot carriers, a fast, 200 ps partial recovery of the bleach occurs. Correlating the changes in optical density and time-resolved photoluminescence strongly support a sub-ns hole transfer from the nanocrystals into graphene.

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