

Charge Separation Dynamics at Nano-Structured Organic/Inorganic Hybrid Photovoltaic Interfaces

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Photo-induced electron transfer and recombination was investigated at the organic/inorganic interfaces of ZnO nanorod and TiO₂ nanoparticle assemblies applying femtosecond transient absorption spectroscopy and THz photoconductivity. The dynamics of different absorber concepts ranging from organic model chromophores to simple light harvesting antenna FRET systems chemically adsorbed on the wide-gap metal oxide electrodes were compared in the complementary experimental setup. Vertically aligned crystalline ZnO nanorod structures grown from self-assembly were recently introduced to challenge the poor conductivity of the sintered TiO₂ nanoparticle films. Especially the absence of grain boundaries in crystalline ZnO nanorods and a much higher mobility predict better directional transport properties in comparison with colloidal TiO₂. Also, the nanorod morphology allows for better phase infiltration of a solid hole conducting medium which is necessary for a long term stability of prospective hybrid devices. However, while TiO₂ dye-sensitized solar cells (DSSCs) are currently still the best performing hybrid solar cells with conversion efficiencies of about 11%, there is quite some controversy why the ZnO based counterparts with efficiencies around 7 % continuously remain inferior. Although both semiconductors have very similar bands gap and conduction band edges, the dynamics of the initial photoinduced electron injection and early back-transfer (recombination) at TiO₂ and ZnO appears to be quite different when sensitized with the same absorber dyes. Especially the initial electron injection process from the adsorbed dye into the surface of ZnO is not well understood.

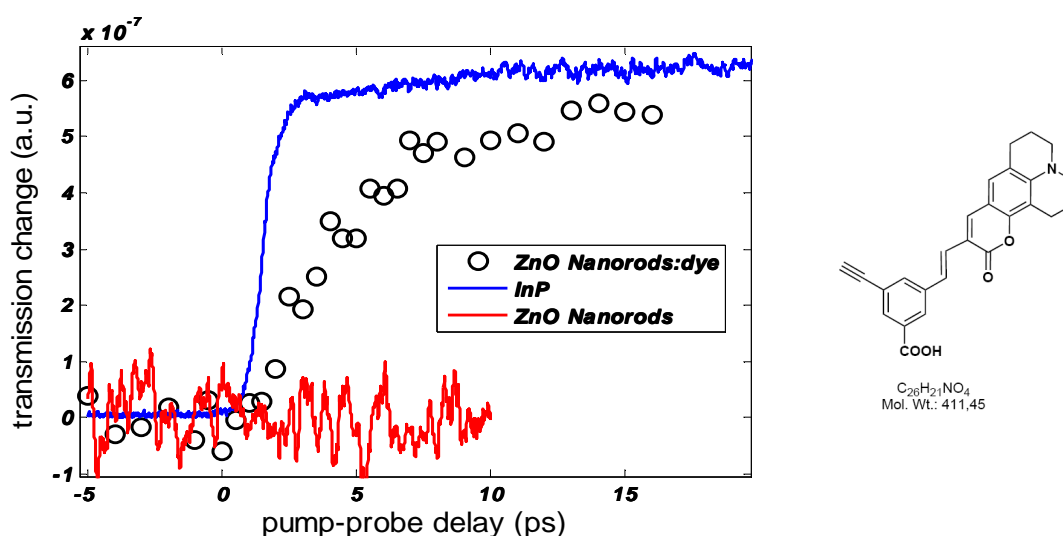


Figure 1: Rise of the THz conductivity (circles) in ZnO nanorods after sensitization from adsorbed coumarin derivatives. The blue curve shows the system rise time, acquired through optical e-h pair excitation in an InP wafer.

A number of mechanisms have been proposed as the main cause limiting an effective charge separation all having in common that the successional bulk escape of the surface-injected electron in ZnO is slow in comparison to TiO₂ leading to a premature interfacial recombination. This effect is experimentally demonstrated by means of fs VIS-NIR spectroscopy and time-resolved non-contact optical pump terahertz probe conductivity (OPTP) as shown in figure 1.

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