**Ultrafast electron dynamics on organic/inorganic semiconductor interfaces**

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Among fundamental issues in photophysics, charge generation and separation/recombination at material interfaces are a primarily important problem to be studied in photovoltaic application. Organic/inorganic hybrid solar cell (HSC) is one of the future generation photovoltaics where the charge separation takes place near heterointerface. The HSC combines organic and inorganic semiconducting materials to meet the demands of high power conversion efficiency, low cost, and environmental compatibility by incorporating the merits of either materials. Furthermore, intriguing physical behavior of hybrid “Frenkel-Wannier exciton” at organic/inorganic hybrid interface results in unique nonlinear optical properties because of significantly different photo-generation mechanism of these two materials. Therefore, in the hybrid system, ultrafast charge transport and separation or recombination mechanisms of charged carriers (exciton) are an important puzzle to be solved out for device efficiency improvement along with each intrinsic material issue.

In this study, we focus on typical semiconducting materials for hybrid photovoltaic system, gallium arsenide (GaAs) as inorganic absorber and fullerene (C60) or copper phthalocyanine (CuPc) as organic counterpart. Four combinations for hybrid system are designed: C60/*p*-GaAs, C60/*n*-GaAs, CuPc/*p*-GaAs, CuPc/*n*-GaAs. We compare each interfacial electronic structure using ultraviolet photoelectron spectroscopy (UPS) and inverse photoemission spectroscopy (IPES). Ultrafast charge transport and separation dynamics are studied by using time-resolved two-photon photoemission spectroscopy (TR-2PPE). Doping type of GaAs and corresponding space charge field control specific charge separation behaviors upon light absorption. While C60/*p*-GaAs shows electron injection or separation to organic acceptor layer [1], CuPc/*p*-GaAs shows hole injection behavior depending on light intensity [2]. In addition, the photo-generated carriers within GaAs exhibit difference time evolution in sub-picosecond range depending on each interfacial electronic structure. Especially, in case of CuPc/*p*-GaAs hybrid system, delayed triplet-state formation in CuPc is observed. Since direct electron excitation within CuPc is neglected, the delayed triplet state is probably generated via “hybrid charge transfer exciton (HCTE) states” [3], which is formed by hole injection from GaAs to CuPc. The lifetime analysis of HCTE and triplet states reveals that the triplet state is closely related to high-energy HCTE state [4]. Finally we discuss about hybrid type material design for enhanced charge separation.

**References**

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