Ultrafast Spectroscopy of Nanostructured Organic Donor-Acceptor Units

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Solar cells made of organic nanostructures are coming of age, as their production costs are much lower than those made by the standard Si technologies, they are flexible and their power conversion efficiency reaches the 10 % range. However, organic materials are bad conductors and there is large room for improving these organic materials in terms of converting the absorbed photons into mobile electron-hole pairs.

In the present project we will be using femtosecond spectroscopy to study the primary photophysical processes in novel Donor-Acceptor (DA) Nanostructures specifically designed for their use in organic solar cells. The time-resolved spectroscopy uses transient absorption and fluorescence techniques to study the kinetics and efficiencies of dissociation of excitons in to charge-transfer states (CT), their possible recombination, and the formation of unbound charge pairs (polarons). While most of the experimental set-up is already existing, some development needs to be done regarding a femtosecond pump-probe experiment with near-IR probing. The candidate is also expected to contribute to the improvement of the femtosecond fluorescence experiment.

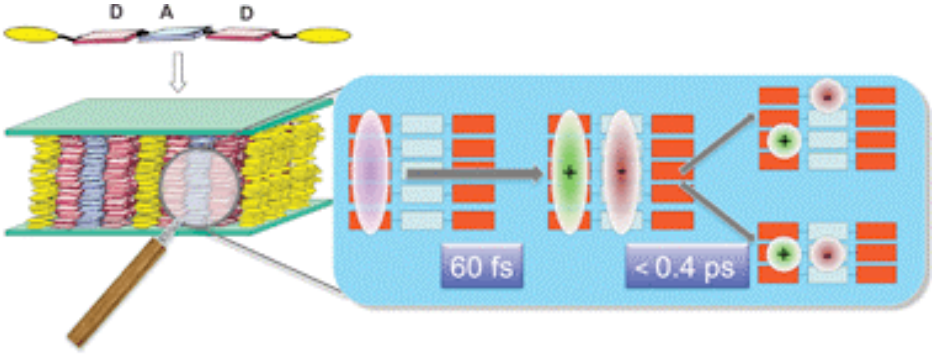

Figure 1: Schematic representation of exciton formation and dissociation in stacked Donor-Acceptor Nanostructures

The thesis project is a collaboration with Strasbourg partners (S. Méry, IPCMS; T. Heiser, ICube). Within the PICASSO and Rhin-Solar networks, the PhD project is contributing to the development of new materials for organic solar cells, as it provides a detailed understanding of the limitations to 100% internal quantum efficiency. In a recent study, we showed how the molecular design can prolong the CT state lifetime in isolated molecules [1, 2] . We need now to extend these studies to the effect of the nanostructured organisation of the molecules in films. The electronic coupling between molecules is expected to be important both for the CT formation as well as for their dissociation. Further, the effect of an external electric field in a solar cell configuration needs to be investigated. An extension of this project could be to contribute to time-resolved THz experiments (to be performed in an international partner lab), which yield complementary information regarding the photo-created free carrier concentration and mobility.

[1] T. Roland, J. Léonard, G. Hernandez Ramirez, O. Yurchenko, S. Ludwigs, S. Méry, S. Haacke, PCCP, **14**, 273–279 (2012).
[2] T. Roland, et al., to be published.