Hybrid Inorganic/Organic Systems for Opto-Electronics

Collaborative Research Centre 951

HIOS

Colloquium Announcement

of the Collaborative Research Centre 951 "Hybrid Inorganic/Organic Systems for Opto-Electronics"

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Organic nanosheets & perovskite nanoparticles: New fabrication schemes for size and interface control

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Charge transfer states at hybrid interfaces

Time: Thursday, October 26, 2017, 3 pm c.t.

Place: Erwin-Schrödinger-Zentrum, Rudower Chaussee 26, Room 0‘119.

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Organic nanosheets & perovskite nanoparticles: New fabrication schemes for size and interface control

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In this talk, I will discuss two recent approaches how to control the interfacial order of organic films on strongly interacting substrates and the nucleation of perovskite nanoparticles. First, we have developed a new transfer technique for organic films [1]. With this approach, which employs low energy electron irradiation, it is possible to deposit organic films on arbitrary substrates including free standing structures. This transfer allows for example to improve injection from bottom contacts into organic films considerably. We expect that this technique will allow us also to fabricate better van der Waals heterojunctions between 2D Materials and organic films, especially in situations, where the growth of the organic film by traditional evaporation techniques is poor. Second, we have used porous films as nanoreactors to nucleate perovskite nanocrystals which show strong quantum confinement, i.e. blue shifts [2]. In both cases, we used synchrotron radiation to probe for the structural details. Especially high energy x-rays turned out to be a very useful tool for depth profiling of micron sized films.

References:

[1] S. J. Noever, et al, Transferable organic semiconductor nanosheets for application in electronic devices, Advanced Materials (2017).

[2] S. Demchyshyn et al, Confining metal halide perovskites in nanoporous thin films, Science Advances (2017).

Charge transfer states at hybrid interfaces

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By definition, charge transfer states (CTS) are related to the ground state via a charge transfer transition. Therefore, the study of the spectroscopic characteristics of these transitions in absorption and emission provides access to the electronic properties of the components forming the CTS, and their interaction at the microscopic level [1,2].

Here, we present the results of recent work on the nature of hybrid charge transfer states (HCTS) at the planar interfaces between metal oxides and organic semiconductors. We find that these states are emissive, and that the emission energy correlates well with the interface energetics measured by photoelectron spectroscopy [3]. Yet, and in contrast to CT states at the organic-organic interface, these hybrid CT states exhibit a distinct dependence of the emission maximum on the applied bias [4,5]. Our studies on model hybrid heterojunctions comprising ZnO and different hole transporting molecules (HTMs) reveal a surprisingly small dependence of the voltage shift on the precise chemical structure of the HTM, on how the ZnO was prepared, and whether or not the metal oxide was photodoped. This finding supports the view that the reported voltage shifts have their origin in electrostatic interactions, but also raise concerns about the nature and localization of these hybrid CT states. Studies on hybrid heterojunctions employing SnO as the inorganic semiconductor provide evidence of state filling in an inhomogeneously broadened density of state distribution as an additional contribution to this effect.

References:

[1] K. Vandewal et al., J. Am. Chem. Soc. 139, 1699 (2017).
[2] J. Benduhn et al., Nat. Energy 2, 17053 (2017).
[3] Piersimoni et al., Phys. Chem. Lett. 6, 500 (2015).
[4] Eyer et al., Appl. Phys. Lett. 107, 221602 (2015).
[5] Panda et al., Phys. Rev. B 94, 125429 (2016).