Squaraine Dyes and Functionalized Silicon Nanoparticles for Printable Electronic Devices

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Abstract

The first part of this work is dedicated to the exploration of the applicability of squaraine dyes as the donor material in solution-processable and, therefore, potentially printable organic solar cells. Several series of squaraine dyes containing donor and acceptor units within the molecule are investigated regarding their performance in solar cells when blended with a fullerene acceptor. The structural optimization of the squaric acid core acceptor subunit and the donor subunits led to a promising squaraine dye with good solar cell performance for solution-processed small molecules. The power conversion efficiency of this dye is 1.79% and the obtained short-circuit current of 12.61 mA cm^{-2} is high for solution-processed small molecules. Some of the investigated dyes show a very interesting aggregation behavior. Two different types of aggregation are identified and characterized, that can be related to *H*- and *J*-aggregates. The selective formation of aggregated domains, only containing one type of aggregation per device, allows the accurate assignment of the morphology impact on the device characteristics. Domain growth is successfully monitored by photocurrent mapping. The impact of the different domains in devices containing more than one domain on the overall device performance is demonstrated.

The applicability of functionalized silicon nanoparticles in printable electronics is investigated in the second part of this thesis. Silicon nanoparticles of different functionalization are used as the active material in solution-processed solar cells and thin-film field-effect transistors. Photovoltaic activity and a field effect are successfully demonstrated for the functionalized silicon nanoparticles containing a hole-conducting organic shell. In contrast, neither photovoltaic activity nor a field effect can be detected for the silicon nanoparticles functionalized with a non-conducting organic shell. Nevertheless, the power conversion efficiency of 0.06% achieved with silicon nanoparticles functionalized with a holeconducting organic shell and a fullerene acceptor is too low to be of practical use. The achieved field effect mobility of 3.4×10^{-7} cm^2 $V^{-1}s^{-1}$ is also very low.