Fundamental Differences between Dye and Quantum Dot Sensitized Solar Cells

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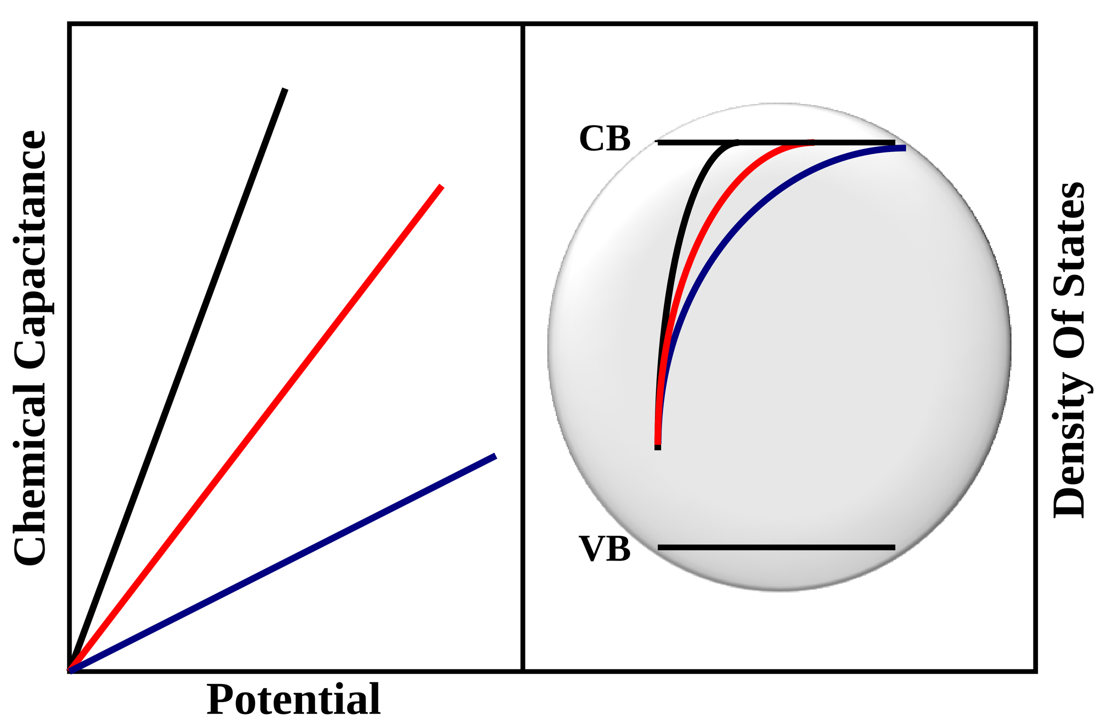
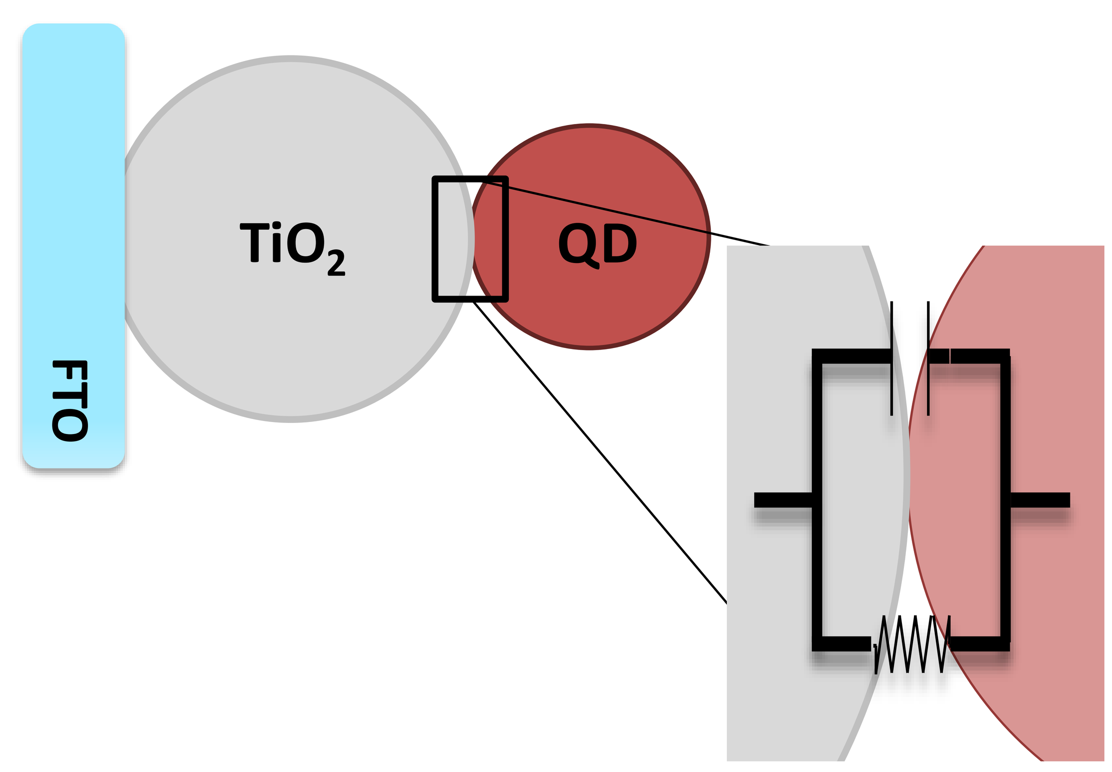
Dye and quantum dot (QD) sensitized solar cells are currently studied assuming that quantum dots behave merely as an alternative inorganic dye. Here we show that this interpretation is not accurate. There is a fundamental difference between dye and QD sensitized solar cells, due to the fact that QDs play a direct role in the recombination process. In this work we show for the first time that the presence of electrons in the QDs during QDSC operation leaves a signature in the capacitance of the system, measured by impedance spectroscopy (IS), demonstrating a fundamental difference between DSCs and QDSCs. In fact, when the electron recombination from QDs into acceptor species in the electrolyte is sufficiently reduced, it is not possible to distinguish between the chemical capacitance of TiO_2 and QDs, at least in terms of IS characterization. In such a case, both TiO_2 and QDs constitute a single entity involved in the recombination process. This result highlights the necessity of treating (and optimizing) QD sensitized solar cells from another perspective than dye sensitized solar cells, considering the fundamental differences in their behavior.

Chemical Capacitance Vs Density Of States



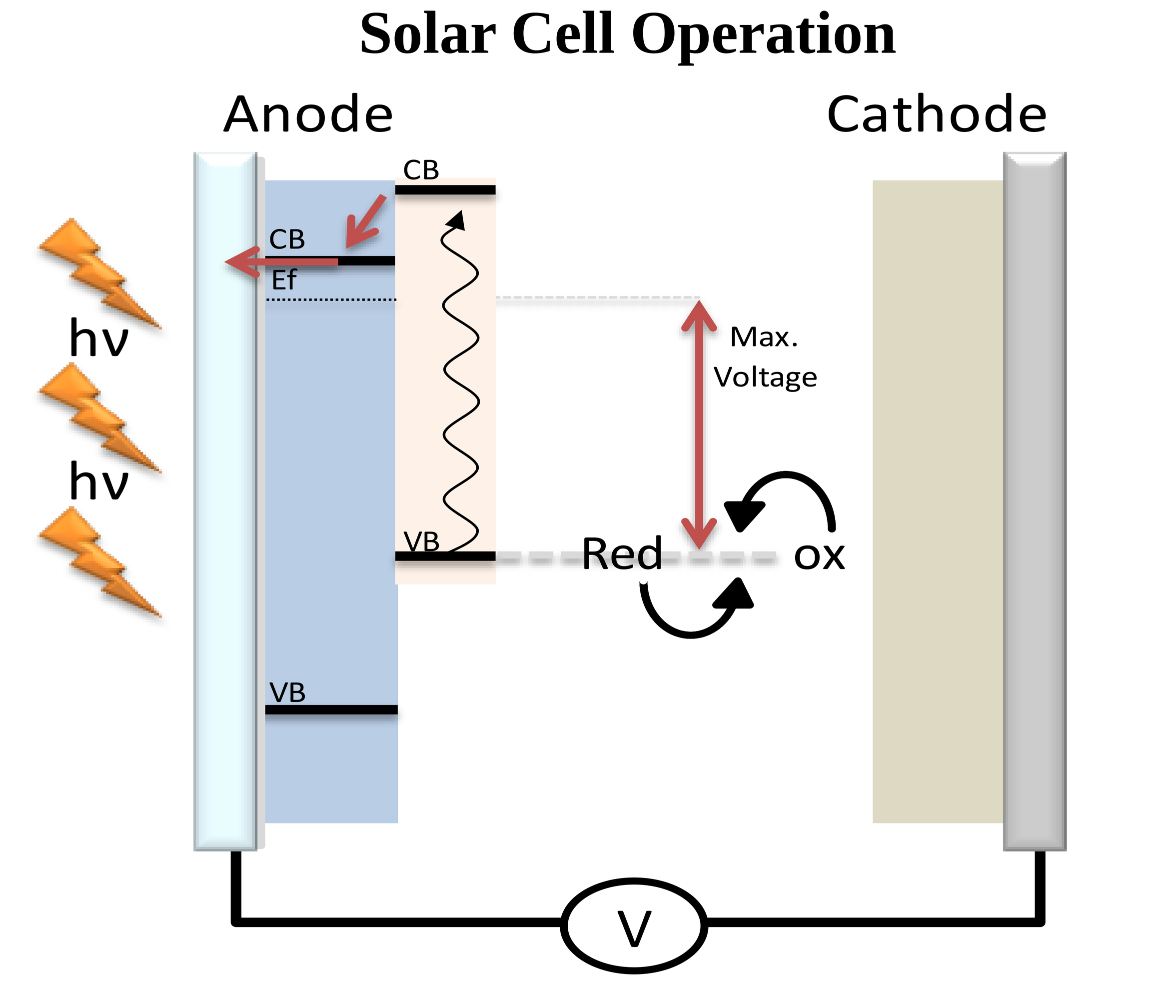
Schematic representation of the relation between the density of states of a semiconductor and it's measured chemical capacitance.

Modeling QDs Sensitized Solar Cells



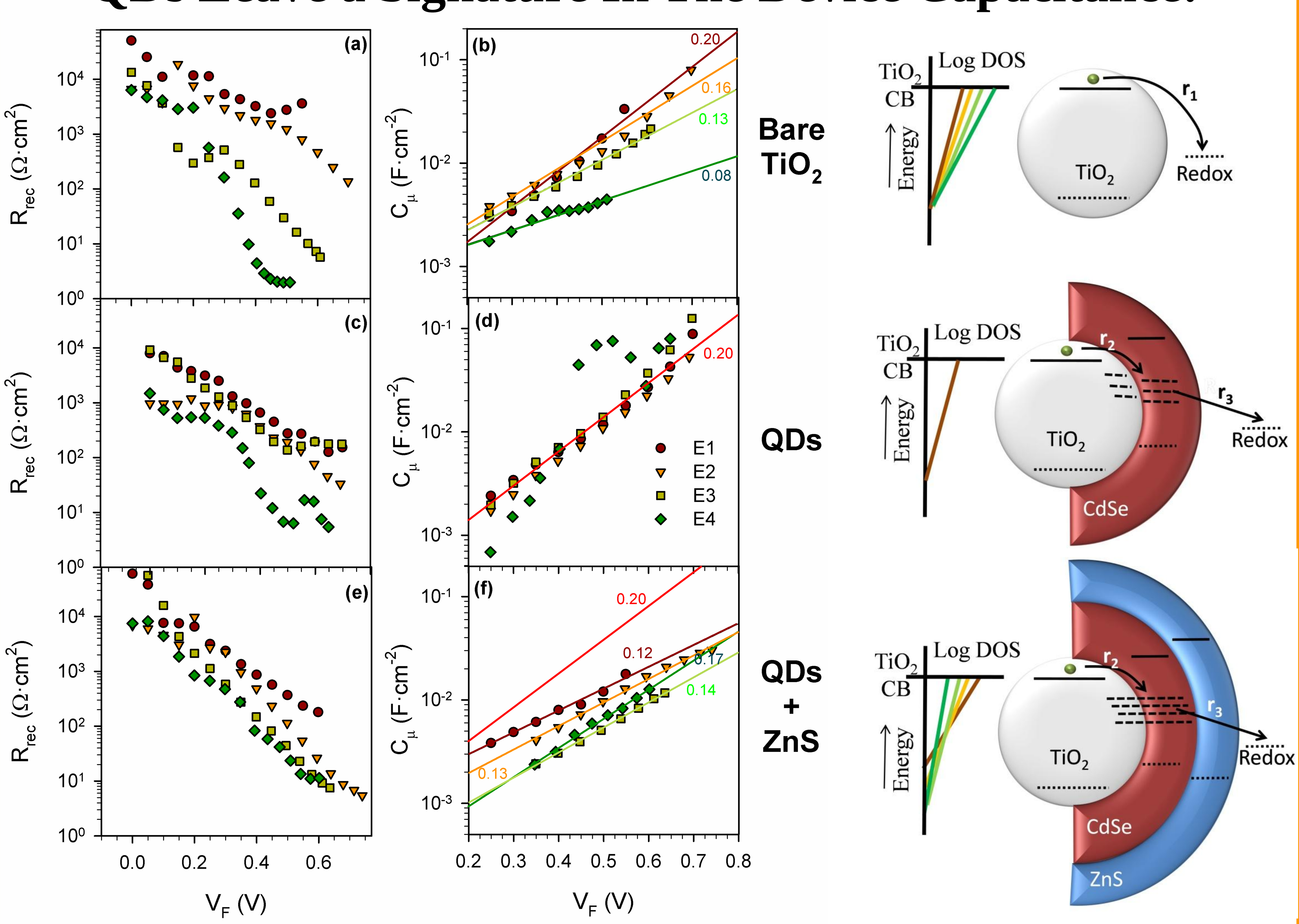
Unlike conventional dyes, QDs contribute to the device capacitance and take a significant part in the recombination processes in the cell.

Solar Cell Operation



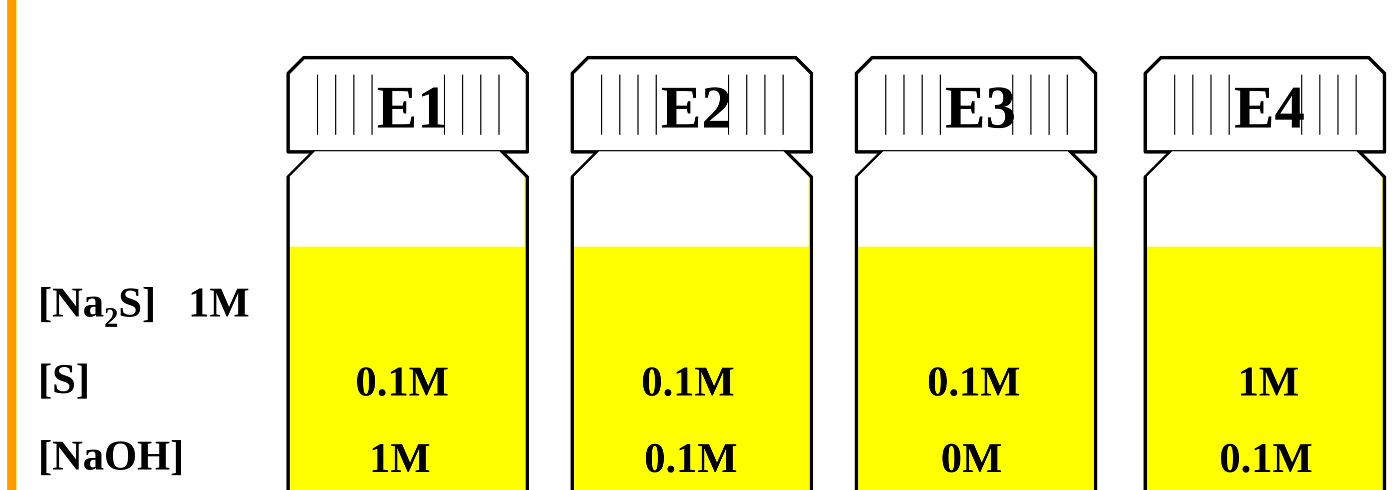
Principle of operation of dye/QD sensitized solar cell. Photo-excitation of the sensitizer is followed by electron injection into the conduction band of the semiconductor. The sensitizer is regenerated by the redox system, which itself is regenerated at the counter electrode by electrons passing through the load.

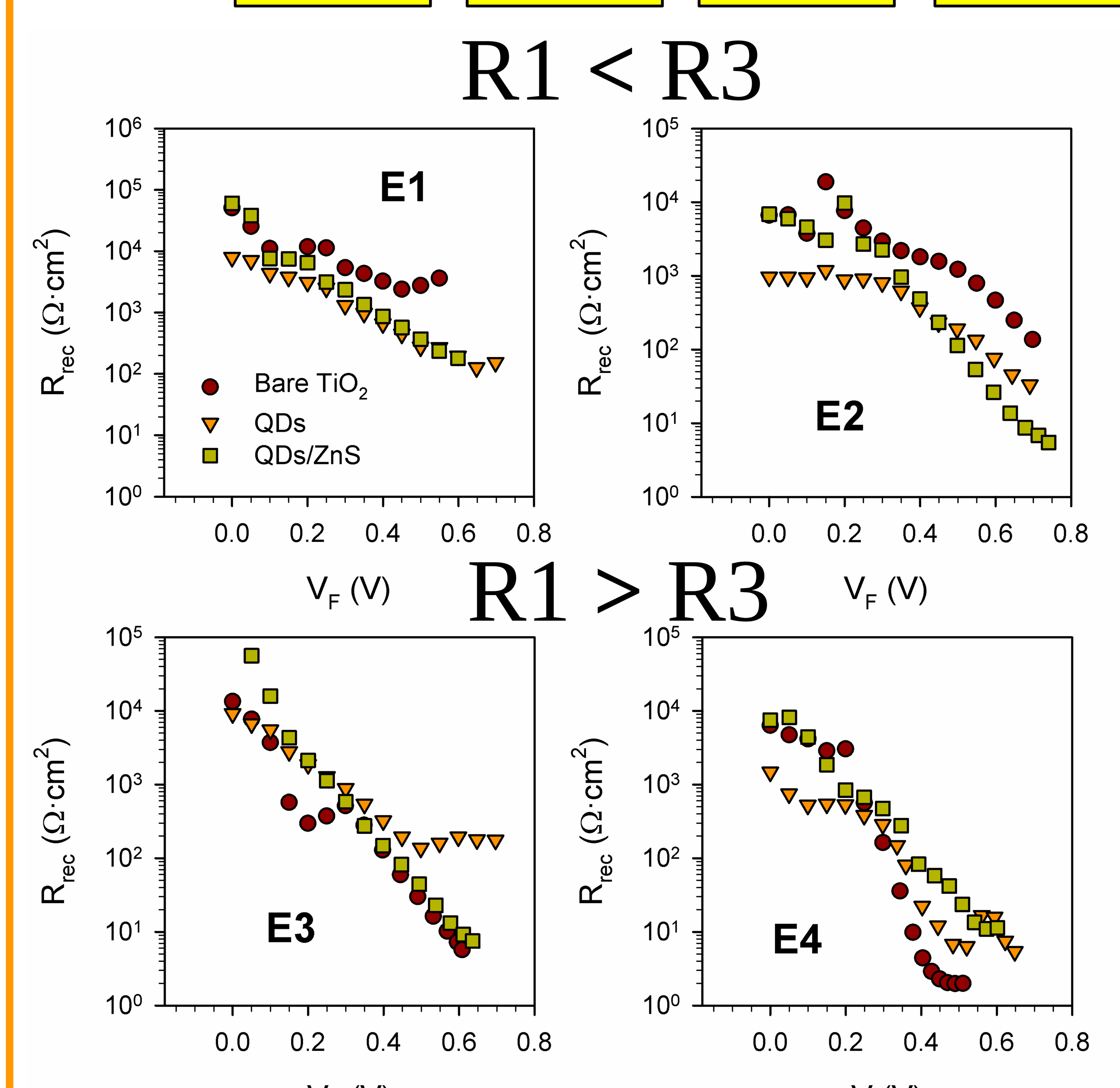
QDs Leave a Signature In The Device Capacitance!



Recombination resistance, Rrec, and chemical capacitance, Cμ, obtained from impedance measurements for QDSCs prepared with bare TiO_2, TiO_2/QDs, and TiO_2/QDs/ZnS electrodes and different electrolytes. For bare TiO_2 electrodes a decrease in the capacitance slope with the number of the electrolyte is observed. For TiO_2/QDs electrodes, independently of the electrolyte used, the capacitance slope is the same and equals the slope obtained for bare TiO_2 and E1. For TiO_2/QDs/ZnS electrodes, regardless of electrolyte type, the capacitance slopes vary from the slope obtained for bare TiO_2 and E1 (this slope is also displayed in the plot, for comparative reasons), indicating a broadening of the TiO_2/QDs/ZnS DOS due to the QDs contribution to the device capacitance.

Recombination Mechanisms can be controlled by the type of electrolyte





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