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Evaluation of ZnO nanorods as a substrate for composite solar cells

It is well known that the transport of electrons within an semiconducting electrode made up of nm colloids as used in the Grätzel cell is very slow, with effective electron mobilities below 10^{-3} $cm^2V^{-1}s^{-1}$ at maximum. This causes a very high excess carrier density even under short circuit conditions so that redox species or hole conductors are required that feature an unusual low bimolecular recombination rate. Otherwise the short-circuit current and overall cell performance will suffer significantly. In practice, only the iodine/iodide redox couple has yet proven to fulfill this requirement. However, even for the original Grätzel cell this redox couple is less than ideal since a significant portion of the achievable photovoltage is wasted.
Single crystal ZnO nanorods can be prepared by cheap wet chemistry methods and promise better electron transporting properties than previous TiO2 colloidal systems. This would allow for a much broader range of hole conducting materials to be used in a composite solar cell configuration. This paper will report on the electronic transport properties obtained from time resolved measurements on complete solar cell structures and bare ZnO nanorod electrodes. The suitability of this new type of electrode for composite solar cells will be discussed.

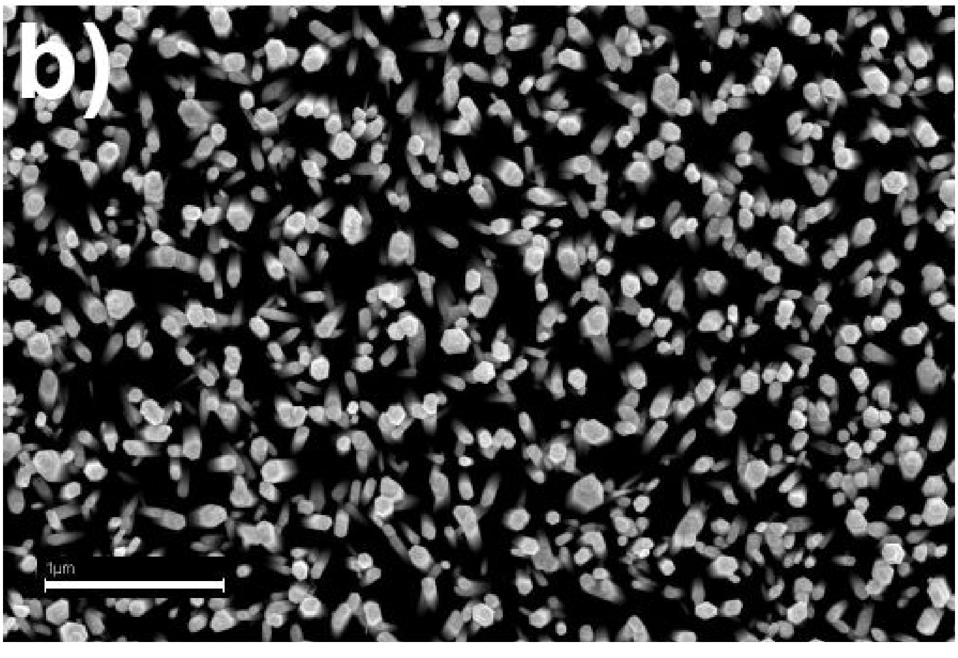

Fig. 1 columnar ZnO film

Columnar ZnO films (Fig.1) were grown from the solution phase on different conducting substrates. Either sputter deposited conducting ZnO films or SnO_2 conducting glass substrates covered with a thin layer of ZnO were used. Photovoltaic cells were constructed in a way very similar to the Grätzel cell preparation, using N3 dye as a light absorber. Photocurrent transients were measured with nanosecond time resolution for complete cells. Bare columnar ZnO electrodes were studied with photo-induced time resolved microwave absorption. Both measurement techniques gave evidence for a reasonably high electron mobility in the ZnO columns. Recombination is slow (us-ms time range) for the bare ZnO film with- or without dye, as well as for the cell under short circuit conditions. However, at least with the present preparation method, a very slow discharge of electrons in the ZnO columns has been found. Fig.2 shows an example of a measured photocurrent signal in response to excitation with a 10ns laser pulse at 532nm (red curve). The simulation with a higher mobility and slow discharge (black curve) is a better match to the experimental curve.

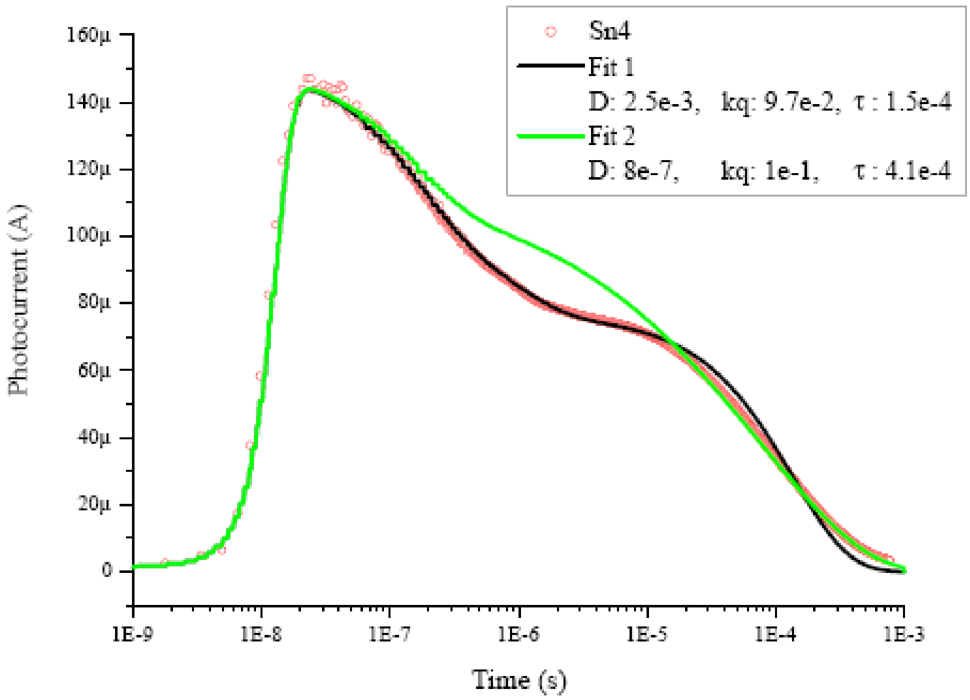

Fig.2 Measured photocurrent transient (red) and modeled signals (black,green)