PHOTOELECTROCHEMISTRY OF MICROSTRUCTURED SILICON MATERIALS FOR SOLAR ENERGY APPLICATIONS

Thesis by

James R. Maiolo III

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Medical Center over a couple of summers with both Ira Ropson and Kay LaNoue, who helped me to learn about research right in my home town.

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Abstract

In the face of mounting evidence that CO_2 emissions from the burning of fossil fuels is a key contributor to anthropogenic global climate change, the search for a carbon-neutral energy source that is scalable and economically viable has become a key research target. Orthogonalization of the directions of light absorption and charge carrier collection in solar cell absorber materials, as in arrays of wires with radial junctions, has the potential to enable the use of low-purity and low-cost materials in efficient solar cells. This work focuses on the use of structured silicon materials as the absorber in semiconductor/liquid junction photoelectrochemical cells in order to verify the potential of structured materials to enable efficient and inexpensive solar cells.

Macroporous Si was used as a physical model system for wire-array solar cells. Using high-purity starting materials, it was found that increasing the surface area by porous etching did not dramatically lower the observed energy conversion efficiency, and efficiencies in excess of 10% were observed even for the longest pores studied. The open-circuit voltage (V_{oc}) was lowered in samples with long pores, however, verifying the principle that a reduction in V_{oc} is expected with increased junction area due to a decreased flux of minority carriers through the junction. This will be an important design principle for building structured solar cells. In addition, diffusion of Au impurities into macroporous Si was used to explore the effect of employing a structured junction in poor quality materials.

Wire array solar cells produced by chemical vapor deposition were also measured in liquid junction cells. Initial studies showed significant photocurrent and photovoltage over the control substrate. Improved arrays having longer wires showed significantly higher photocurrents, giving energy conversion efficiencies as high as 1.5% in the liquid junction cell, and it has been shown that the photoelectrochemical properties of the wire array samples are due to the CVD-grown wires rather than the silicon substrate used. These results are an important first step toward understanding and building efficient, low-cost solar cells using structured materials.

Online Availability

Chapters 2 and 4 of this work have been previously published in American Chemical Society (ACS) Journals. Per ACS policy, those chapters cannot be made available online to the general public. However, free copies of the original papers are available by using the internet addresses shown below. Please note that a one-time, free registration is required to download the papers.

Chapter 2 - http://pubs.acs.org/cgi-bin/download.pl?jp711340b/o498

Chapter 4 - http://pubs.acs.org/cgi-bin/download.pl?ja074897c/Q7Lo

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