Strategies for Scaling Up Solid State Photosystem I-based Devices for Solar Energy Conversion

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Abstract

In order to commercialize solid state solar cell devices, it is important to show that they can be scaled up to industrially relevant sizes. Photosystem I (PSI)-based solid state devices for solar energy conversion have shown to yield an appreciable photocurrent over small surface areas. However, devices with larger surface areas have so far not been synthesized. This research project focuses on the fabrication and testing of solid state p-Si/PSI/ZnO/ITO solar cell devices of 4 cm diameter and 6 cm diameter.

Background

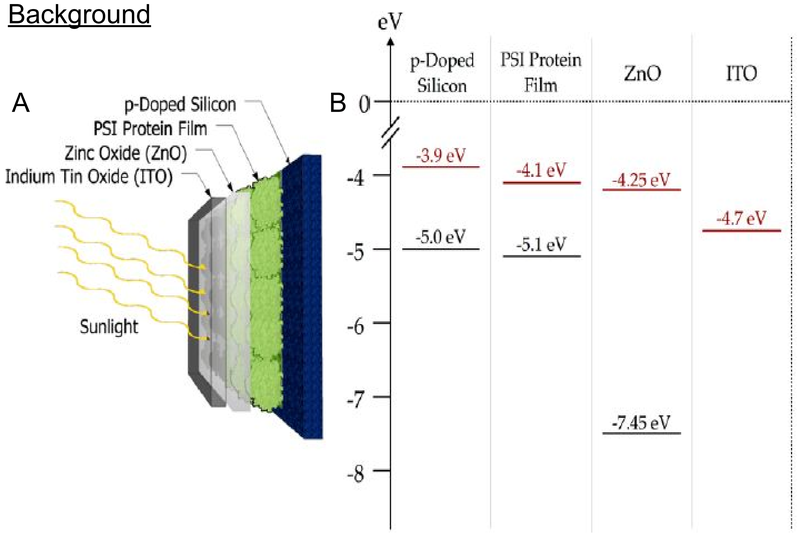

Figure 1: Device Structure and Energy Diagram[1]

(A) Architecture of a solid state p-Si/PSI/ZnO/ITO photovoltaic device. (B) Energy diagram for the same device. When sunlight hits the PSI film, an electron-hole pair is created. Because of the alignment of the valence and conduction bands of the different components, the excited electron is then transferred from the PSI to the ZnO and then to the ITO, and the hole is transferred from the PSI to the silicon.

Results and Discussion

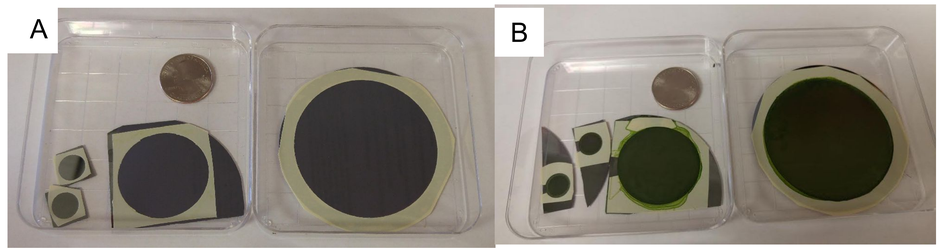

Figure 2: Scaling Up - Three Device Sizes

(A) Silicon wafers were prepared with a mask. (B) Multiple layers of PSI were deposited onto the silicon.

100µL of a 2.8µM PSI solution was used per cm^2 of silicon. The PSI was drop cast onto the silicon and at first it was dried using a vacuum chamber. The vacuum chamber caused the solution to freeze, yielding a very rough film of PSI. The vacuum chamber was therefore replaced by a vacuum oven at 60°C to prevent the sample from freezing, yielding a more uniform PSI film.

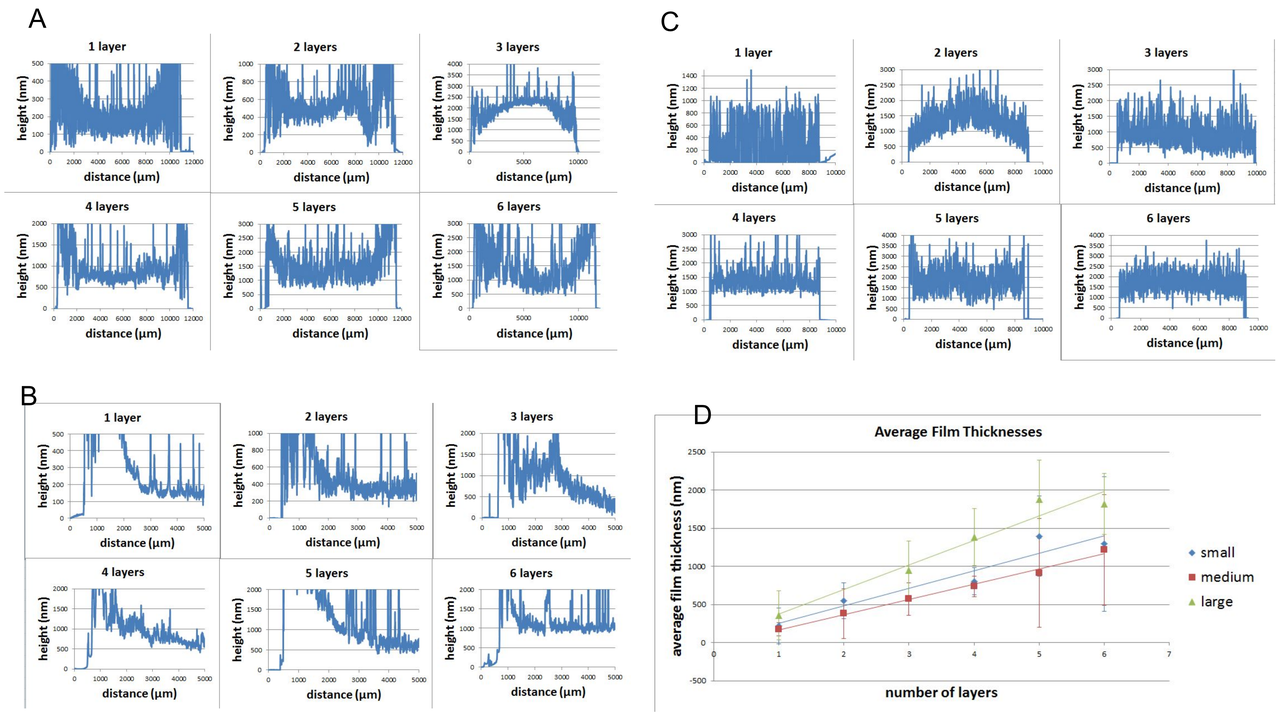

Figure 3: Profilometry Data

Profilometry data from PSI deposited on silicon for (A) 1 cm-, (B) 4 cm-, and (C) 6 cm-diameter devices, which have an area of 1 cm^2, 11 cm^2, and 32 cm^2 respectively. (D) Trends in film thickness for the different layers and device sizes.

Future work

Once the PSI is deposited onto the silicon, the next step is to deposit a zinc oxide layer on top of the PSI. Next an indium tin oxide cover is pressed onto the device to seal it. Once the complete devices are fabricated, the next step is to test them for photocurrent and longevity.

Acknowledgements

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References

[1]J. C. Beam, G. LeBlanc, E. A. Gizzie, B. L. Ivanov, D. R. Needell, M. J. Shearer, G. K. Jennings, C. M. Lukehart, and D. E. Cliffel, *Langmuir*, 2015, **31**, 10002-10007.