CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

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Project Number

31412

Project Title

Increasing Silicon Solar Cell Efficiency by Improving Light Absorbance with Near-Zero Reflectance Nano-Textured Surface

Abstract

Objectives/Goals

Silicon based solar cells are important in the green energy market. To improve efficiency of these devices, improving the light absorbance of the silicon surface is important. In industry, a common technique is to texture the surface and improve light trapping capability. This project investigates a novel surface texturing method and assess its improvement in both cell light absorbance and cell efficiency.

Methods/Materials

The structure investigated is known as silicon nano-towers, or SNTs. Three heights of SNTs (types A (2 um), B (4 um), C (8 um)) are created, characterized and applied to the construction of mono-crystalline p-doped CZ silicon solar cells. Contact metals used for the solar cells were Al on the backside and Ti/Ag on the front side. The n-dopant was phosphorus. The optical reflectance was measured with an ellipsometer after the SNTs were created. Wavelengths over a range of 3000A to 10,000A for incident light angles from 20 degrees to 80 degrees from the normal were tested. To build the solar cells, I created the SNT structure on the silicon wafer, created the p-n junction, etched SiO2 and did the metal coating, and then tested efficiency.

Results

Optical:

The results showed that for incidence angles of 60 degrees and below, reflectance of the type B and C SNTs was < 0.1%, and for the type A, < 2%; at the more pertinent 40 degrees incidence all three showed a reflectance of < 0.1%.

Efficiency:

Solar cells built with type A SNTs had the best overall efficiencies and the highest improvement over the control. The maximum efficiency recorded was 14.2%, and the average improvement for the type A SNT cells over the control was 57% (or an average absolute efficiency improvement of 5.5%).

Conclusions/Discussion

Though the type C cells had the best (lowest) reflectance, the average efficiency change for the type C cells was negative. In contrast, the type A cells, though they had worst (highest) reflectance, had the best efficiency improvement. This phenomenon is related to the direct relation between surface area and carrier recombination, indicating a need to optimize the height of the SNTs (since type A was the best,the optimum is probably around 2 um). Future work will involve characterizing cells built with SNTs on solar grade FZ material and multi-crystalline silicon to assess the full potential of the SNTs.

Summary Statement

I built silicon solar cells and textured them with a black-colored nano-structure to improve cell efficiency: the result was an improvement 5.5% raw efficiency (8.7% control to 14.2% modified), potentially reducing cell cost/watt by 30%.

Help Received

Allvia Inc. provided facilities and mentoring; Tango Inc. provided metal deposition capability; Stanford Nanofabrication Lab provided doping capability; Kent State Ohio University provided optical testing capability; RETC provided efficiency testing capability; Dr. Achintya Bhowmik provided guidance.