Incorporation of Silicon Nanoparticles into Silicon Based Solar Cells

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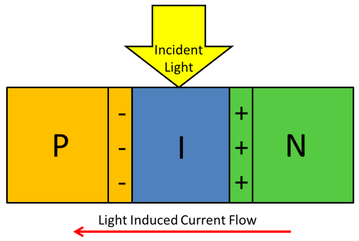
Introduction

In this project, silicon based solar cells were developed using active layers that consisted of Amorphous Silicon as well as Silicon Nanoparticles (Silicon Quantum Dots). The ultimate goal of this project was to fabricate a working solar cell with an active layer that incorporated Silicon Nanoparticles in an attempt to improve cell functionality.

Photovoltaic Cells

PIN junctions

- P and N type doped material layers create an electrical field.
- Middle insulating layer (I) absorbs light and produces charge carriers (electrons and holes).
- Electric field separates carriers and creates voltage difference.
- Gives photovoltaic cells diode-like behavior and ideally allow for unidirectional current flow.
- Two way current flow allows for carrier recombination and reduces cell efficiency.

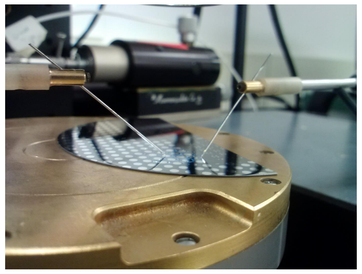


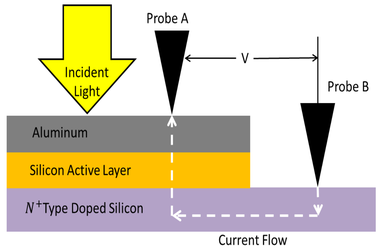
Quantum Dot Benefits

- Size tunable band gap.
- Potential for multiple electron hole pair production at high energy levels (avoids energy loss due to thermalization).

I-V Characterization

- Uses two probes in contact with opposite ends of active layer on the surface of the sample to measure current flow versus voltage through the cell.
- Helps determine diode-like behavior in cells and other characteristics such as the Open Circuit Voltage, Short Circuit Current, and Fill Factor.

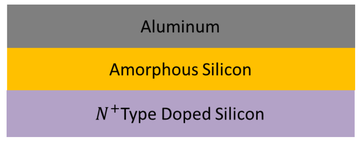


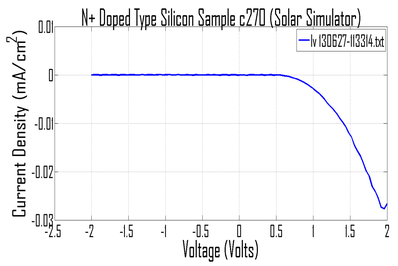


Fabrication and Test Results

Metal-Insulating-Semiconductor (MIS)

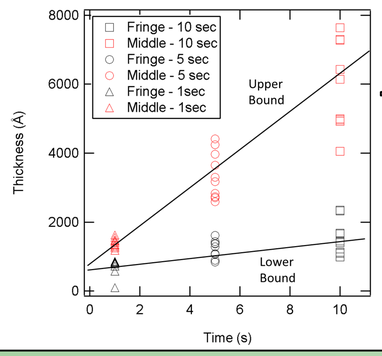
- Produced strong diode behavior and unidirectional current flow.
- Top aluminum contact prevented light penetration into cell.

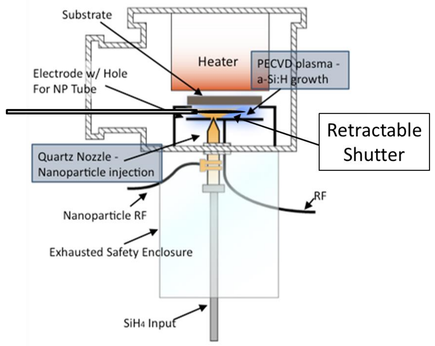




Nanoparticle Reactor

- Preliminary testing was run on reactor to discover the particle deposition rate.
- Shutter installed to prevent transient deposition rates in reactor and attain constant thickness.



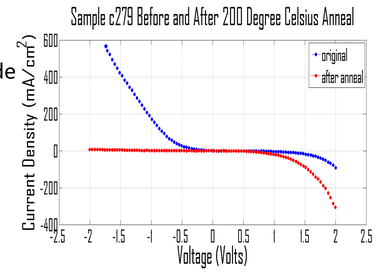


Preliminary Nanoparticle Cells

- Sample MIS prototype cells fabricated using silicon nanoparticles as insulating layer with aluminum contact on N+ type silicon doped wafer.
- Diode-like behavior was present but diode was leaky.

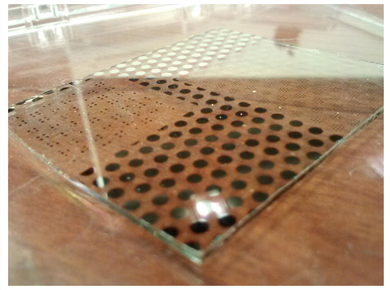
Annealing

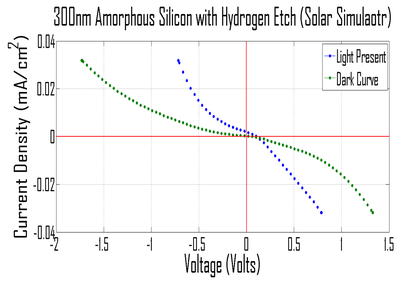
- MIS cells treated at 200 degrees Celsius for 5 minutes.
- Aluminum doped adjacent silicon quantum dot layer creating P type Silicon.
- Junction became more completely formed and diode behavior was improved.



Metal-Insulating-Metal (MIM) Transparent Solar Cells

- Fabricated cells with transparent top layer in order to produce light current
- Cells constructed from glass, Indium Tin Oxide (ITO), Zinc Oxide, Amorphous Silicon, and Aluminum.
- Slight light current produced (positive current and voltage in first quadrant indicates power produced by cell).
- Cell leakage was present (weak diode behavior).

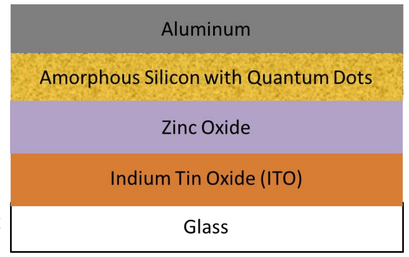




Conclusions

Accomplishments

- Fabricated MIS cells with amorphous silicon and Quantum dots that displayed strong diode behavior.
- Confirmed advantages of annealing in MIS solar Cells.
- Improved accuracy of Nano-Particle Reactor deposition rates.
- Produced small amounts of light induced current in MIM solar cells.



Further Steps

- Test effects of annealing on transparent MIM cells.
- Incorporate a combined amorphous silicon and quantum dot layer.
- Determine optimum concentration of quantum dots in amorphous silicon matrix.

Acknowledgements

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