Final Year Project 2009-2010

Microcrystalline Silicon Deposition
Modeling, Fabrication and Characterization of Solar Cells (MW1b-09)

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Project Overview
With rising energy costs and the depletion of fossil fuels, solar energy has become the most promising source of renewable energy. However, with the high price of solar-grade silicon and its large fluctuations, traditional means of producing solar cells using silicon bulk substrates prove to be uneconomical. One solution is the use of thin film technology which can be fabricated on cheaper substrates.

Microcrystalline silicon, which consists of silicon in both amorphous and crystalline phases, is one type of silicon-based thin films that shows the most potential in achieving affordable solar cells.

Objectives
1. Achieve the first deposition of microcrystalline silicon at HKUST’S Nanoelectronics Fabrication facility (NFF).
2. Analyze and compare the deposited microcrystalline film to current industry standards.
3. Give recommendations on future deposition of microcrystalline silicon here at HKUST.

Methodology
Previous work on the deposition of microcrystalline silicon was reviewed to extract the deposition conditions and recommendations for the project. Research on the characteristics of optimum solar-grade microcrystalline silicon was also done for comparison.

Using a Design-of-Experiments approach to screen the factors and fixing the frequency at 13.56 MHz and the hydrogen flow-rate at maximum, the resultant input variations were studied through 12 distinct depositions.

After careful consideration, the Plasma Enhanced Chemical Vapour Deposition module at NFF was chosen for this project. The system allows for 5 input parameters shown in the accompanying diagram. Variations in these parameters would determine the characteristics of the resultant silicon film.

Results
The films were successfully deposited using the PECVD at NFF.
Figure 4 shows the XRD spectrum from the sample with the highest crystallinity.

From the results of the deposition and characterization, it was determined that the maximum film crystallinity was 22.37%, with a crystalline orientation preference for the (220) plane over that of the (111) plane at 0.41 for Sample 4. The maximum growth rate achieved was found in Sample 6 at 68.9 Å/min.

The missing data in the table was due to peeling of the deposited film, resulting in unsuitability for characterization.

Conclusion and Recommendations
The project successfully deposited microcrystalline silicon using the PECVD system at HKUST’S Nanoelectronics Fabrication Facility. However, the maximum crystallinity of 22.37% is far below the optimum 65% and the crystalline orientation preference for (220) is insufficient for solar cell production.

This is due to the limitations of NFF’s equipment and it is recommended that further work be done using VHF-PECVD systems with high deposition pressures.