# New Simplified process for creating heterojunction solar cells

*Researchers examine the characteristics of a new method of manufacturing heterojunction solar cells which could potentially make them simpler and cheaper to produce.*

Rapid Thermal annealing (RTA) is the process in which a semiconductor is quickly heated in order to activate dopants and affect other electrical properties. RTA can also be used in order to crystalize amorphous silicon to lower sheet resistance. University of Waterloo PHD candidate, Christopher Baldus-Jeursen recently published a paper in which he and his collogues used low thermal budget RTA to create an intrinsic layer. Christopher, who is part of the Centre for Advanced Photovoltaic Devices and Systems at Waterloo, then preformed standard measurements for solar cells such as Raman Spectroscopy, dark and illuminated voltage characteristics and UV-Reflectance spectroscopy. Their research shows that the device has an efficiency of about 14%.

One of the most promising solutions for solar cell devices is using both amorphous and a crystalized cells together, known as a heterojuction. The deposition process, in order to produce them, can be a complex undertaking the cells have many layers. What is noteworthy about Christopher's research is that it simplifies the manufacturing process because it eliminates a need for a conductive oxide layer. "When amorphous silicon is crystallized by RTA, the charge carrier mobility increases greatly. The sheet resistance of the n-type films has been determined to be between 90-120 Ohm/square which is sufficiently low to allow lateral movement of charge carriers to the front contacts. Thus, no transparent conducting oxide is needed." In the paper Christopher wrote: "The simplicity and low thermal budget nature of RTA systems can be an attractive alternative in PV device applications."

The defining feature of a heterojunction solar cell is that they contain two different semiconductor layers, each with a different band gap. Another difference is that the amorphous layer is used for passivation for the crystalline surface. This will increase the recombination rate of the crystalline. Heterojunctions have efficiencies of 20% compared with normal thin film solar cells (11%). They are also cheaper than pure crystallized solar cells.

The efficiency of using RTA is dependent on the thermal budget. "The thermal budget is the product of the annealing temperature and the annealing time. An example of a high thermal budget process would be dopant diffusion for a diffused p-n junction solar cell which usually requires temperatures up to 900°C for at least 30 minutes." Chris wrote. In order for the RTA process to be effective at crystallizing the amorphous silicon, it is desirable to have a low thermal budget. "High temperature processing is undesirable because it can cause warping/deformation of the silicon wafer due to stress (particularly as wafers become thinner). High temperature can also reduce the wafer minority carrier lifetime especially if the wafer has a high concentration of impurities." The amorphous silicon was annealed at temperatures between 600°C and 800°C for 5 minutes.

Christopher preformed the tried and true Raman analysis on 3 different cells that where annealed at 3 different temperatures. The graph displayed a small shoulder at 480cm-1 due to the intrinsic layer and a giant spike at 520cm-1 due to the substrate. "The height of the shoulder at 480cm-1 is very small because the film is extremely thin. If thicker films were used (say 1000 nm thick) the height" states Christopher. UV spectroscopy was used instead to find the crystallization fraction because the wavelengths reflected are much shorter at 200nm.

The obvious trend here is that as temperature increased the amount of crystallization was greater. However, when asked what would happen if the annealing time was increased instead of the temperature the answer was not clear: "That's a complicated question, and it's still something I am investigating. Longer annealing times at higher temperatures can reduce defects in the crystallized film (as determined from Hall Effect measurements). However, long annealing times can also cause problems such as peeling off the film from the substrate and pin-hole formation caused by the explosive out-gassing of hydrogen from the amorphous silicon as it crystallizes."

The electrical characteristics including Dark and illuminated I-V curves were plotted and analyzed Open circuit voltage and short circuit current values were obtained for each temperature and the fill factor increased as the annealing temperature increased (figure 6). This means that the efficiency increased to 13.9% at 750°C.

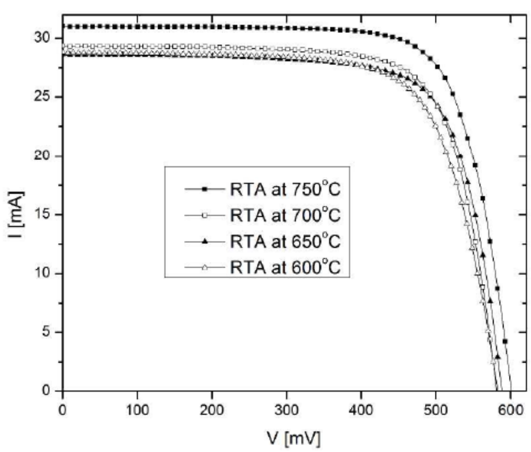


**Figure 6:** Solar simulator illuminated I-V curves under one sun.

The interface between the two different semiconductors is most likely to affect the efficiency of the cell. This is most likely due to the fact that micro-twins, "crystal defect which consists of two parts as mirror images", become scattering centers at the junction and hinder performance. It was found that annealing temperatures above $750^o$ reduce the micro twin density drastically as can be observed by the higher shunt resistance.

At an efficiency rate of 13.9.% , the heterojuncton cell using a rapid thermal annealing process looks to be a pretty good alternative method for manufacturing solar cells due to its low thermal budget and lack of a TCO. The next steps in their research is to do further ellipsometry analysis at different annealing temperatures in order to get a better sense of the composition ratio between amorphous and crystalline silicon.