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Project 09 - Nanowire Photovoltaics
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Diversity in Canadian Photovoltaics Research

As part of Stream 2, we had the opportunity to hear from Canadian leaders in photovoltaic (PV) research. It was fascinating to see how the Canadian PV research community was extremely diversified, with research endeavors and collaborations spanning the full spectrum of PV technologies. We also heard from public policy experts and gained an improved understanding of the role of the federal and provincial governments on the implementation of renewable energy production. Finally, the opportunity to converse and collaborate with fellow Canadian researchers provided perspective and motivation to continue working in the rewarding field of renewable energy.

Question 1: What is the current status of the Ontario FIT (feed-in tariff) program for photovoltaics and what are the short and long-term outlooks?

The Ontario feed-in tariff (FIT) program is an incentive program with the purpose of encouraging renewable energy production while creating jobs and encouraging research and development into renewable technologies. The FIT was first introduced when the *Green Energy and Green Economy Act 2009* was passed on May 14, 2009. As of August 13, 2010, rooftop solar PV installations producing less than 10 kW to the power grid received the maximum rate of 80.2 ₵/kWh [1]. Larger rooftop and ground PV installations receive progressively lower rates, with the lowest set at 44.3 ₵/kWh. The small capacity rooftop installations are those most likely to be adopted by residential owners, whereas larger rooftop or ground based PV systems are pursued by businesses.

During the PVIN Annual Network Meeting, a keynote presentation was given by Elizabeth McDonald, President of CanSIA. In this presentation, Elizabeth touched on the important role the FIT program has played in propelling Ontario onto the world stage as a leader in renewable energy, particularly with PV. The investment that Ontario has made in the FIT program has already manifested itself in billions of dollars of renewable PV energy through private sector investment including over 30 solar manufacturing facilities. As a result, Ontario had the 2nd largest PV market in North America in 2010 and was home to the largest solar park installation in the world – the Sarnia Solar Project, which produces enough electricity for 12,800 homes.

In the long-term, the outlook for the Ontario FIT program is not clear. Elizabeth informed us that there was a general political consensus that the FIT rates would be reduced by the end of this year. However, there is uncertainty regarding the magnitude of this adjustment and whether certain Ontario political parties completely opposed the FIT program altogether. The question then raised was whether this uncertainty works against what the FIT program is attempting to achieve as it is well known that PV is a capital intensive, long-term investment and relies on the FIT to cover the system costs within a reasonable period of time (10 – 20 years). Uncertainty in the FIT rates or their existence generates risk for investors in renewable energy technologies. Political instability regarding FIT programs in other countries has resulted in decreased participation and thus reduced effectiveness.

Moving forward, it would be prudent for the Ontario political parties to agree that renewable energy will be a vital part of Ontario's energy grid, to devise a clear roadmap for how FIT rates will evolve, and to make a commitment not to play with these rates for the sake of partisan politics. Under a stable FIT program, Ontario can expect to remain a world leader in the renewable energy industry, including solar power. The resulting investment in Ontario leads to substantial job creation while simultaneously replacing dirty energy production from coal plants. As energy prices continue to rise, PV energy prices will continue to fall and the FIT program will become less needed. However, as Ontario will have an established renewable energy industry due to the FIT program, it will be in a position to supply less forward-looking foreign and domestic markets with renewable energy products.

[1] http://fit.powerauthority.on.ca/Storage/11128_FIT_Price_Schedule_August_13_2010.pdf

Question 2: What are the current design challenges facing III-V tandem solar cells

III-V tandem solar cells give the highest efficiencies of all PV technologies. Two junction tandem cells were first introduced in the 1980s and by the 1990s they outperformed crystalline silicon cells. Three junction tandem cells have since been introduced and have attained efficiencies as high as 42.4% under concentrated sunlight. However, tandem cells are intrinsically expensive as they rely on high costs substrates and complicated epitaxial thin film depositions systems. Therefore, tandem cells have captured only niche markets such as on spacecraft or in large concentrator systems.

Two generally accepted paths to reducing tandem solar cell costs are to increase efficiencies and to decrease manufacturing costs. The efficiency of tandem solar cells may be enhanced by better understanding their operation through computer simulation, optimization of each layer's bandgap through the introduction of new materials, and enhanced absorption and collection of light through improved anti-reflection coatings and transparent front contacts. There are many aspects of tandem solar cells that make them expensive to manufacture. Current triple junction tandem cells use germanium substrates, which are very expensive and thus alternatives are being rigorously pursued. Additionally, epitaxial deposition technologies have been traditionally expensive and slow, but new multi-wafer systems will assist in driving down costs.

Question 3: Silicon has dominated the PV market since its birth, but thin film technologies such as CdTe are growing fast. Is there a place for silicon PV in the future market?

When the solar cell industry first began it was built on the back of the semiconductor industry, which was largely founded in using silicon for integrated circuits. In many ways, silicon is not an ideal material for PV as it does not strongly absorb sunlight due to its indirect bandgap; however, the dominance of silicon in the semiconductor industry meant that it was manufactured in large quantities and it could be made exceptionally pure for good optical and electrical properties. Therefore, the first generation of PV is often defined as the generation of crystalline silicon solar cells. These cells were made from the same kind of wafers that integrated circuits manufacturers used. Consequently, these wafers were very thick, which wasted silicon, and were prohibitively expensive.

In order to decrease the cost of solar, the second generation of PV introduced thin film technologies that use minimal amounts of semiconductor material. Currently CdTe thin film solar cells are reaching the lowest \$/Watt values ever achieved, which is a major step forward for the PV industry. However, there are many reasons not to abandon silicon based solar cells as silicon is an exceptionally abundant and environmentally friendly material. Currently, research is being conducted into silicon technologies such as ultra-thin silicon, amorphous silicon, and silicon micro and nanowires. These technologies offer highly reduced manufacturing costs compared with first generation silicon PV. Optimization and progress in light trapping technologies will enable these emerging silicon technologies to improve efficiencies and remain competitive in the second generation PV market.