



Investigation of Recently Developed Photovoltaic Material

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Photovoltaic devices (Solar Cells) convert sunlight directly into electricity. This research project is directed toward decreasing the cost of Solar Cells.

“Yearly the earth receives 6000 more times energy from sunlight than humans use. **Photovoltaic solar cells** produce no greenhouse gases, so their use could reduce the probability of global warming and climate change. In 1997, solar cell module shipments jumped to 125 million watts, resulting in more than \$1 billion in sales. At present growth rates (which averaged 24% for the last 5 years) module shipments will surpass 10 billion watts per year by 2020. This would represent a direct photovoltaic market greater than \$15 billion and an indirect market double that. Today, the solar cell industry creates about 3000 direct and indirect jobs for every \$100 million of module sales. As this industry grows toward its potential, it will generate hundreds of thousands of jobs.” [National Center for Photovoltaics]

“Currently, the photovoltaic research work likely to make the largest impact upon the industry has been that allowing a transition from silicon wafer-based technology, to that of thin films supported on a foreign substrate, such as polycrystalline silicon film on glass. The material intensiveness of the wafer-based approach limits the potential for cost reduction and hence the possible long-term impact of the technology. It seems likely that a mature thin film approach will displace wafer technology over the next 10 years.” [M. Green: Key Center for Photovoltaic Engineering, University of New South Wales (UNSW), Australia]

Purpose of Experiment

These experiments were designed as a first step toward developing more cost efficient solar cells. To realize this goal, low cost fabrication techniques to deposit thin polycrystalline films of materials necessary to create photo-voltaic cells various must be developed. Current techniques to deposit the thin films require high temperatures to promote crystalline growth. These high temperatures limit the type of substrates that can be used.

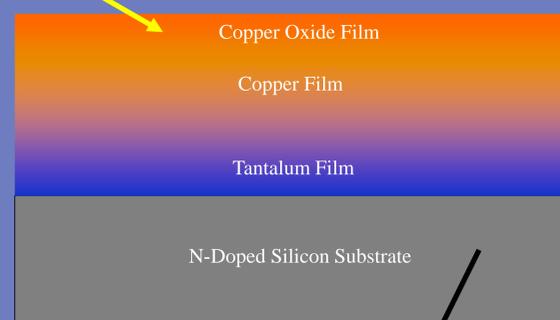
Our technique involves using an unique deposition system that has been under development at UW-Eau Claire. This system incorporates a unique plasma source with capabilities that, in theory, should allow the deposition of crystalline films at low substrate temperatures on a variety of substrates.

These initial experiments were designed to investigate whether photovoltaic devices can be fabricated with this system.

Photovoltaic Cell Design

Photovoltaic cells that convert sunlight to usable electric power can be designed in a variety of ways. The design we investigated involved first depositing a thin film of tantalum on a silicon substrate that had been treated to increase its native conductivity. Next a very thin film of copper was deposited and subsequently bombarded with low energy ions to increase the temperature of the growing film. This causes the tantalum and the copper to mix and form a metastable alloy. Finally the surface of the film was exposed to air to create copper oxide film at the surface. This process created a semiconductor layer adjacent to a “Schottky Barrier” layer. This system successfully converts light to usable electric power.

Sunlight In



Electric Power Out

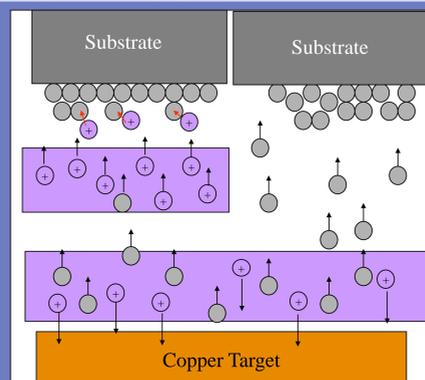
Dual Plasma Arc Thin Film Deposition System



Ion Beam Assisted Deposition Technique

A plasma can be created using the DC-TRIODE ion source system. Ions are accelerated out of the plasma and impinge on the target. Subsequent collisions between these incident ions and atoms in the target cause atoms from the surface to be ejected toward the substrate. These atoms deposit on the surface to create a thin film.

A second plasma arc is created and ions are accelerated toward the substrate to bombard the growing film and alter the film’s properties to enhance certain characteristics. In this case the attempt was made to enhance the photovoltaic properties of the film.



Photovoltaic Cell Properties

The photovoltaic properties of the cells was determined using a high intensity white light and digital multimeter (DMM). The light was positioned a certain distance away from the cell to provided a consistent level of illumination intensity at the surface of the cell. The DMM was used to determine the “open-circuit” voltage and the “short-circuit” maximum current. These two properties are commonly used to assess the overall performance of photovoltaic cells and together they determine the maximum power the cell can delivery.

Experimental parameters were adjusted to improve the performance of the cells. **Over a 1000 percent increase in performance was achieved.**

Sample	Open-Circuit Voltage	Short-Circuit Current	Maximum Power (Percent Improvement)
#1	0.060 Volts	0.1 μ Amps	0.006 μ Watts (0%)
#2	0.140 Volts	0.1 μ Amps	0.014 μ Watts (230%)
#3	0.140 Volts	0.3 μ Amps	0.042 μ Watts (700%)
#4	0.250 Volts	0.3 μ Amps	0.075 μ Watts (1250%)

Conclusion & Future Directions

The results of this project indicate that while further improvement of the photovoltaic cell design is possible the efficiency is far below that available with other cell designs currently available. It is believed that damage in the crystalline structure of the film due to the ion bombardment step reduces the efficiency of the cell.

Future experiments will concentrate on using electron bombardment from the plasma instead of ions to promote crystalline growth. This should reduce the amount of damage in the film and in theory that would result in higher photovoltaic conversion efficiencies.

Acknowledgements

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