These two new solar cells will have a current equal to $I_o/2$, but a voltage equivalent to $2V_o$. If we repeat this method to create 4 cells, then we see that we will have current equal to $I_o/4$, but a voltage equivalent to $4V_o$.We can show this with the diagram in Figure 2.

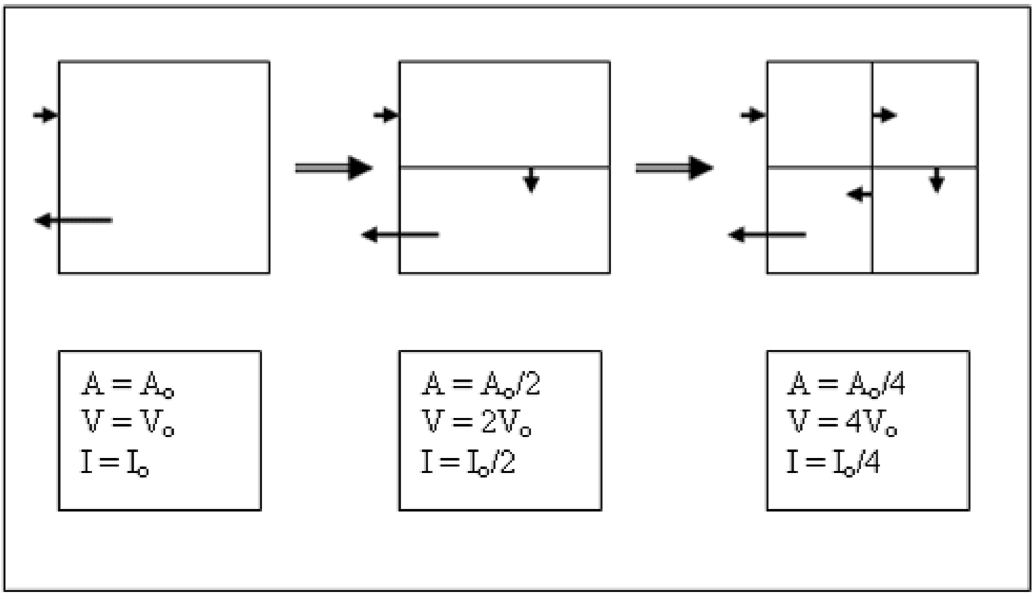

Figure 2. Solar Cell Arrangement

Metal Insulator Semiconductor (MIS) solar cells

A drawback of using solar cells is that there is the initial carbon cost of producing the solar cell. Once produced the cells produce power without any additional carbon dioxide output.[7] Many companies have developed solar cells that are cheaper to produce but have a decreased efficiency. An older technology that seems to have fallen out of favor for development is the MIS solar cell. The fabrication steps for this type of solar cell are simple and the efficiencies are comparable to the newer technology cells[8, 9].

Inverted pyramid technology is being used on traditional diffusion solar cells resulting in an increase in efficiency. This would be another method to explore to further increase our process efficiency. This technology has also been applied to MIS solar cells.[10] The costs for producing the MIS solar cell are low because there are only a few raw materials needed to produce the cell. It consists of the silicon wafer and aluminum on both sides of the wafer. We can see the basic side view for the MIS solar cell in Figure 3. There is a layer of silicon dioxide, but that is for the operation of the cell. Also included is an antireflective coating, which has been shown to increase the performance of solar cells[11]. Our solar cells have an appearance similar to that shown in Figure 3.

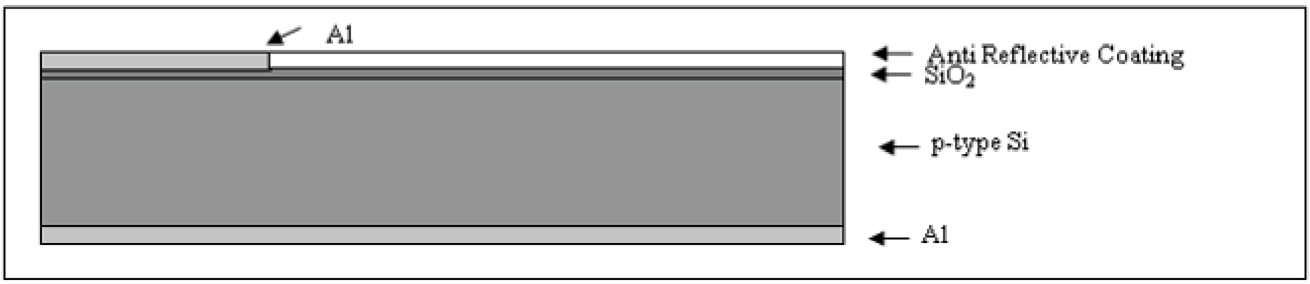

Figure 3. MIS solar cell side view

In addition to being environmentally friendly, MIS solar cells have relatively simple processing steps. The time to produce one MIS solar cell is less than that of a diffusion solar cell because of the reduction in materials and processing steps as a result of fewer materials being needed. Since the processing of MIS solar cells is simple we could incorporate the fabrication of MIS solar cells in a solar cell educational course. This would enable the college to promote the fact that it actively trains students in green technology. The processing steps involved can also be shared with different colleges so that they may also educate students with green technology. The fact that the amount of materials used in processing is low makes this point even more attractive to colleges that are under tight budget constraints.

MIS drawback

MIS solar cells have a problem in that they degrade under continued exposure to sunlight [12-14]. This is perhaps the reason why they were left by the wayside. We have verified that there is in fact a degradation over time but also that the level of degradation seems to taper off over time as well [14]. In an attempt to correct for this we looked into methods of reducing the internal resistance of our solar cell process to help compensate for the MIS solar cell degradation.

Diffusion solar cells

Once MIS solar cell degradation was verified, we decided to review the usage of normal diffusion solar cells and how we can improve that process for our facilities. We looked to reduce the internal resistances (series and shunt) of the solar cell. We used SPICE models to show that as the resistance values increase the power output of the solar cell decreases. The models also showed that for our current output regime shunt resistance plays a part in power output also. The models that we used are shown in Figure 4. The series resistance was 5Ω and the shunt resistance was chosen to be 10kΩ. The outputs for those models are shown in Appendix C.

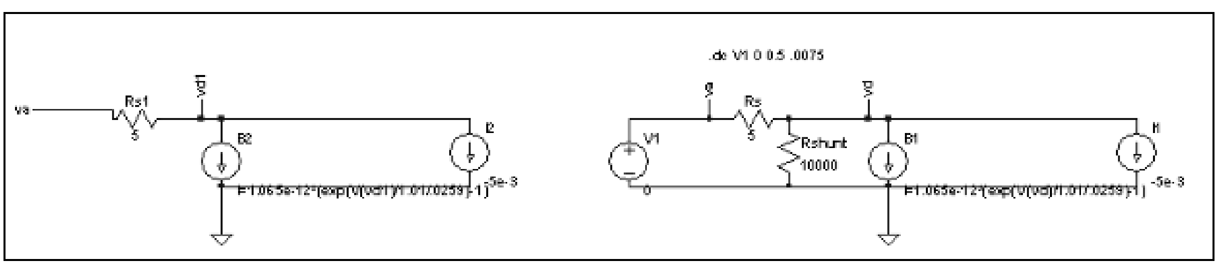

Figure 4. SPICE model for solar cell

Experiment:

MIS and diffusion solar cells were made in the Microscale Process Engineering Laboratory (MPEL). The wafers used had the following parameters:

- Orientation: 100
- Thickness: 475-575 um
- p-type
- Doping concentration: 10^{14} /cm^3

Designing the Shadow Mask

First, taking into account the reasonable open voltage and short circuit current that can be measured with the available lab equipment, the dimension of our solar cell was determined as 2 centimeters by 2 centimeters. With this specification, only nine cells can fit in each wafer. Also, the smallest feature that can be used in a shadow mask is about 0.5mm. Therefore, the width of the bus was chosen to be 5 mm and the fingers 0.5mm. Five values were determined for the spacing between the fingers. They were 3mm, 4mm, 5mm, 6mm and 7mm. After the grid was designed, the shadow mask used in the process was made by sending a CAD file to the SJSU Machine shop. The shadow mask is a thin copper plate that has been laser cut. There are nine 2 cm by 2 cm cells on the mask. When using the shadow mask in the evaporator we taped the mask onto the wafer on four sides with polyamide tape. This tape was non-reactive inside of the evaporation chamber. Since the combined wafer and shadow mask became thicker it was necessary to tape the backside to the evaporator to ensure the wafer did not slip. The way the shadow mask interacts with the wafer can be seen in Figure 5. Later, during testing of the first two batches of solar cells, we found that a ring was needed to cover the backside of the wafer during aluminum deposition to prevent the metal going over the edge of the wafer and short circuiting the diodes. The ring was designed with a bigger diameter than the wafer so that it can cover the edge of the wafer. It was also designed to be 5mm in width so that a bigger area of the backside of the wafer can be covered by aluminum.

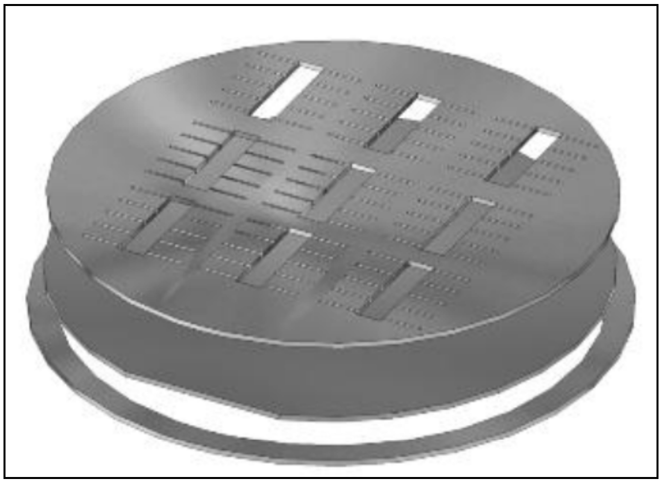

Figure 5. Shadow mask

Procedure for MIS solar cells

The processing steps used for producing the MIS solar cells are shown in Appendix A. Two wafers were used in each batch of solar cells produced. Each batch was verified working by testing the V_{OC} of the entire wafer prior to scribing and testing individually.

Procedure for diffusion solar cells

The processing steps used for producing the diffusion solar cells are shown in Appendix B. Two wafers were used in each batch of solar cells produced. Each batch was verified working by testing the V_{OC} of the entire wafer prior to scribing and testing individually.