**Introduction**

Nowadays, quite a number of manufacturers use (Al)InGaP/InGaAs/Ge structures grown lattice-matched on Ge substrates for the manufacture of triple junction solar cells, with their maximum efficiency of ~29% (1 sun AM0). It is believed that a junction with band-gap between those of GaAs (1.44eV) and Ge (0.67eV) would further enhance the efficiency, but no convenient bulk material existing that has lattice-matching with Ge.[1]

While emphasis has been placed on lattice-mismatched metamorphic growth of InGaAs on Ge to achieve lower band-gaps, imperfections have often appeared from the mismatched growth [1]. A method to improve the efficiency of a triple junction solar cell has been based on materials lattice-matched to InP. The use of InP-based materials has been advocated on the grounds that lots of lattice-matched materials with smaller band-gaps are easily obtained. It has been proposed that the quaternary InAlAsSb can attain a direct band-gap as high as 1.8eV, appropriate for the top junction within a multi-junction device, while lattice-matched to InP. This can be combined with the quaternary InGaAlAs to attain a lattice-matched solar cell with three or more junctions [1]. However, this method from our perspective is expensive. We have seeked to simulate to obtain a more cost-effective solar cell.

**Methodology**

**Simulation of a triple junction solar cell**

Two pieces of software were made. The first one is a calculator written by JAVA, in which we insert the values of the band gaps of semi-conductors, short circuit current, open circuit voltage, fill factor to calculate the efficiency. The second one is a calculator written by mat-lab, in which we insert the values of the short circuit current, open circuit voltage, series resistance and shunt resistance of the solar cell, to plot the I-V curve of the solar cell.

**Radial Solar Cell Fabrication using Microwires**

For planar solar cell to reduce recombination of charge carriers, we have to use materials with long diffusion length that exceeds 1/u. Such material will make manufacturers incur a high cost. In contrast, radial junction solar cells using microwires can produce a large current using less expensive semiconductor with small diffusion length just like the wire radius of such type of solar cells. The great length of the microwires enable large optical absorption while the short radius of the solar cell allows the collection of a large amount of charge carriers. See the figure below from http://opscience.iop.org/2040-8986/14/2/024006/article.

![Solar Cell Diagram](image)

Under AM1.5 condition using shunt resistance =98892ohm and series resistance= 0.01ohm, if the bandgap of the top sub-cell (bandgap 1) of a triple junction solar cell is 2.0eV, the bandgap (bandgap2) of the middle sub-cell is 1.4eV and the bandgap (bandgap3) of the bottom sub-cell is 1.1eV. The short circuit current is found to be 19mA/cm^2, the open circuit voltage 3.60V, the fill factor 0.9579 and the efficiency 37.96%.

Using AM1.5 condition and our experimental data, we have analysed the maximum efficiency of a triple junction solar cell and a double junction solar cell.

The highest efficiency of a triple junction solar cell is found to be 45.70%, with bandgap1=2.1eV ± 0.05eV, bandgap2=1.4eV ± 0.05eV and bandgap3=0.9eV ± 0.05eV. In order to fabricate a triple junction solar cell with the highest efficiency, the bandgap combinations should be 2.1eV, 1.4eV and 0.9eV.

**Results**

References: