ABSTRACT

After the fabrication of the first silicon p-n junction solar cell, tremendous amount of research work has been performed by various researchers to improve its efficiency. Various new designs of solar cells were developed over the years. In the present thesis the performances of three different types of solar cell structures, namely

(i) Schottky-barrier solar cells
(ii) Metal-insulator-semiconductor solar cells and
(iii) Quantum well solar cells

have been investigated theoretically.

In Chapter 1 a detailed review of existing literature has been undertaken and an introduction about the work carried out in this thesis has been given.

In Chapter 2 of the thesis an analysis of a Schottky-barrier silicon solar cell has been carried out. Schottky-barrier solar cell (SBSC) is a metal semiconductor junction in which light falls on the front metal surface. The Schottky-barrier solar cells are more advantageous than the conventional p-n junction solar cells due to their simple and economical fabrication process. In this chapter, the dependence of the excess minority carrier distribution and the photocurrent of SBSC, on doping concentration and the back surface recombination velocity have been studied analytically. On the basis of this study a new design of the SBSC with a back surface field (BSF) has been suggested, which is expected to give much improved performance.

In Chapter 3, some theoretical studies on the back surface field Schottky-barrier solar cells has been carried out and it has been observed that it indeed gives much better performance than the conventional SBSC.

In Chapter 4, the performances of metal-insulator-semiconductor (MIS) solar cells have been investigated theoretically. Though Schottky-barrier solar cells are easy to fabricate and inexpensive, but due to their high dark current, the open circuit voltage and the conversion efficiency of such cells are lower than the conventional p-n junction solar cells. An efficient way to improve the performance the SBSC is to introduce an insulating interfacial layer between the metal and the semiconductor interface, which is known as the metal-insulator-semiconductor
(MIS) solar cell. In this chapter, the dependence of the conversion efficiency on the interfacial layer width and on the back surface recombination velocity has been studied analytically. The variation of the conversion efficiency with doping concentration of the base region of the cell has also been investigated.

In Chapter 5, an analytical study on the AlGaAs/GaAs QWSC has been carried out. Quantum well solar cell (QWSC) is one of the most high efficiency solar cells. After the fabrication of the first QWSC, various kinds of research work have been performed on QWSC by different researchers during the last two decades. There are mainly three types of current components present in QWSCs, namely the tunneling current, the thermionic emission current and the photo-generated current in the n-type base region. Assuming the rectangular barrier model of the QWSC, the temperature dependence of the three current components as well as the total current of the cell, has been studied theoretically.

In Chapter 6, assuming a trapezoidal barrier, the tunneling current of AlGaAs/GaAs QWSC has been studied analytically. The tunneling current of a quantum well solar cell has been studied previously assuming a rectangular potential barrier. However, the barrier created in the intrinsic multiple quantum well (MQW) region of a quantum well solar cell (QWSC) appears to be trapezoidal in nature. Therefore, in this chapter, a trapezoidal barrier has been considered and the expression for the tunneling current of the QWSC has been obtained. The variation of the tunneling current with temperature has been shown graphically and for the purpose of comparison, the corresponding variation of the tunneling current with temperature, assuming a rectangular potential barrier has also been shown. It has been found that while the magnitude of tunneling current corresponding to the two models is different, the nature of variation with temperature is similar. In addition to this, the expressions for temperature and wavelength dependent refractive indices of different regions of the QWSC have been taken into account while performing the calculations of reflection coefficient. Solar cells having different well width and barrier width have been chosen and the variation of the tunneling current densities with wavelength of incident light and temperature of the device has been studied for each cell. It has been observed that the tunneling current density falls with increase in the temperature of the cell.

In Chapter 7 a conclusion of the entire thesis has been given and suggestions for future work have been discussed.