# SOLAR CELLS

## INTRODUCTION

As fossil fuels continue to deplete, development and research in sustainable power generation like solar energy is of utmost importance. Even though solar energy is always accessible, challenges arise because the power conversion from solar to electrical is not efficient. The energy payback time- that is the time taken for a device to generate as much energy as was needed to fabricate the device should also be acceptable. Above all, production cost should be low. Therefore, technological advancement, improvements in device design and choosing better materials are some ways by which we can reduce the cost of solar cell devices at the same time increasing its efficiency. In this text, operation of solar cells is examined, followed by a brief introduction of 3 interesting papers on solar cell development.

## OPERATION OF SOLAR CELL

Solar cell is a photo diode. When light falls on it, electron hole pairs are generated in the n-side, the p-side and the depletion region. Due to the generate carriers, a current flows from n to p region which is $I_{op}$. As optical generation rate increases this current increases. This current adds to the normal reverse current of the diode. If we open circuit the photo diode a voltage less than contact potential $V_o$ appears across the pn junction. This is $V_{oc}$.

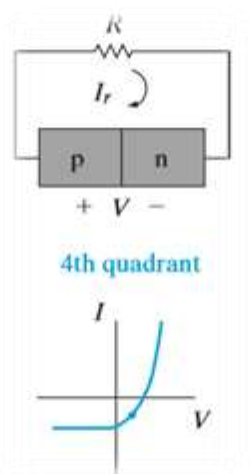


FIGURE 1 VOLTAGE IS POSITIVE, CURRENT IS NEGATIVE, CURRENT FLOWS INTO THE EXTERNAL CIRCUIT

$$Iop = qAgop(Lp + Ln + W)$$

$$Voc = \frac{kT}{q}\ln\frac{gop}{gth}$$

Where $g_{th}$ = thermal generation rate and $g_{op}$ = optical generation rate, $L_p$ is diffusion length of holes in n region and $L_n$ is diffusion length of electrons in p region and W is depletion region width.

$V_{oc}$ and $I_{op}$ are important parameters because they give the value of voltage and current obtained from a photo diode. In the 4$^{th}$ quadrant operation of the I-v curve. Applying a positive voltage to the device, we obtain a negative current, that is current is driven towards the load. Hence light energy gets converted to electrical energy. A typical design of a photo diode for a solar cell is as shown in figure 2. The depth d is kept less than Lp, so that holes generated holes generated near the surface to diffuse to the junction before they recombine. The area that faces the light is large, for

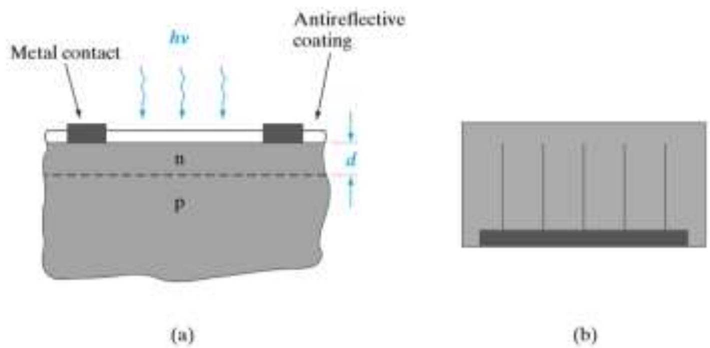


FIGURE 2 A- TYPICAL SOLAR CELL B- TOP VIEW OF N CONTACTS

maximum exposure to the sun. Metal contacts are designed in such a way that there is minimum ohmic losses. The metal contact on the n region can be distributed like fingers as shown in figure 2 b, to reduce the ohmic loss as well maintain exposure to the light.

Even though the currents obtained from a single cell is minimal, many cells add up to give appreciable outputs. Solar cells have established powering satellites, remote locations and various consumer products like garden lights.

Fill factor is an important figure of merit for solar cell. The maximum power delivered to a load by the solar cell occurs when the product $VI_r$ is a maximum. Calling these values of voltage and current $V_m$ and $I_m$, we can see that the maximum delivered power illustrated by the shaded rectangle in Fig. 3 is less than the $I_{sc}V_{oc}$ product. The ratio $I_mV_m$ / $I_{sc}V_{oc}$ is called the fill factor,

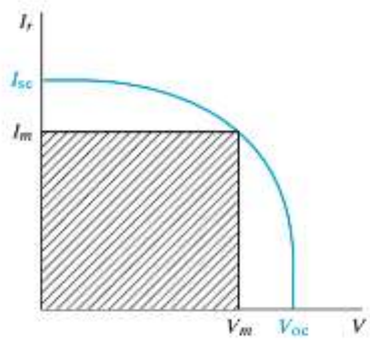


FIGURE 3 FILL FACTOR