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MATCHING OF VISIBLE RANGE PHOTON ENERGY WITH THAT OF SEMICONDUCTIVE MATERIAL BAND GAP ENERGY

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Abstract- *Solar energy in the form of photovoltaic (PV) conversion is one of the most important potentials for green electricity generation without fuels is becoming competitive energy as electricity. Problem to the researchers is to match band gap with solar spectrum properly, conventional PV systems can not utilize the intercepting huge amount of solar energy to the earth properly converting it to electricity. So, multilayer PV system has been analyzed using MATLAB program in form of absorption coefficient for proposing an efficient solution of energy demand. A model has been proposed for deposition of multilayer film in laboratory at low cost. Taking into account this proposed method, matched with VRPE of wavelength 380nm to 750nm (3.6294eV - 1.6565eV) multilayer film is possible to obtain. From such film, very high absorption is obtained that is in practical more than 30% efficiency depending upon the constraints in the form of PV output is possible.*

Keywords: Multilayer film, band gap, photon energy, match and constraint

1. INTRODUCTION

The sun is a giant ball mostly hydrogen that is constantly undergoing fusion nuclear radiation to form helium and the process of releasing huge amount of radiation energy. In the scheme of capturing solar energy comes down in the earth in small fraction of its total radiation either as heat or as photon energy, two main systems are adopted, thermal systems and photovoltaic systems.

Thermal system captures the sun's heat energy (mainly infrared radiation) in some form of solar collector and use it to mostly to provide hot water [8, 9] or for space heating [8, 9] but the heat can also be used to generate electricity directly heating the working fluid in heat engine which is turn drives in generator.

Photovoltaic system captures the sun's higher frequency radiation; mainly in the visible range energy is released in the form of photons, an array of semiconductor photovoltaic cells which convert the radiant energy directly into electricity [11].

Interest in depositing multi-junction film has been motivated by capability of capturing solar energy to generate electricity in considerable scale in the form of photovoltaic effect and the demand of modern technologies.

This paper aims to show the amount of absorption improvement due to properly matching of activated range photon energy with that of semiconductive material band gap energy arranging and depositing multi junction as solar cell film with conventional solar cell film of corresponding material for more electricity generation. Amorphous silicon solar cells have been fabricated in different devices structure. These include single junction p-i-n and n-i-p devices as well as schottky barrier cells, MIS cells and several different types of multi junction cells. Moreover a-Si solar cells have been fabricated on variety of different substrates such as glass metal foils and plastic [1-3] the major constraint on the substrate material is that if must be able to accommodate temperatures of at least 120ºC and not contaminate the a-Si films during deposition [1, 2, 4, 5] and we have used in this case glass substrate to overcome the difficulty of out of order property of silicon when the substrate fails its flat shape due to using plastic or something like this as a substrate.

To increase in absorption of incident light, sufficiently long lifetime of photo excited electrons and holes, and effective separation using multi junction cells is the way to obtain better efficiency of a solar cells. As well limitation of light induced degradation which exhibits all amorphous silicon based solar cells is typically 20% or 30% before reaching the steady-state. The degradation depends in the device and film structure and deposition condition. At the same time it is important the annealing kinetics of these cells under a variety of illumination and bias condition [3, 6, 7]. Also different band gaps of materials have been arranged (3 layers) within the range of total gap energy of visible light and corresponding band gap has been taken into account for single layer for comparison of absorption characteristics between these two cases by programming approach.

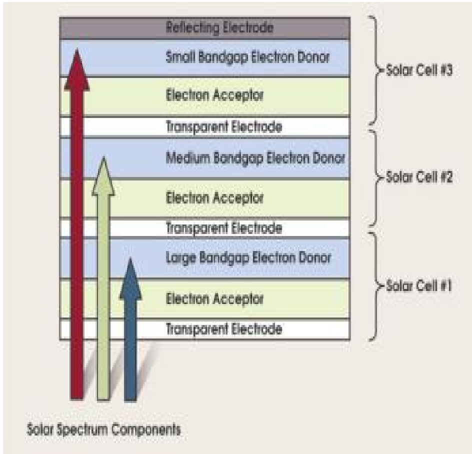

Fig.1: Various portion of solar spectrum are absorbed at a range of places in a multi junction solar cell

2. PROPOSED MODEL

The proposed experimental model is applicable only for low cost application and it is only a model for prototype. In the model, a table fan (single phase induction motor) has been used for main part in where mounted vane or rotating blade or flat blade was a part of the fan would rotate under the action of electromagnetic force has been detached from the shaft. After that, a thin alumimium sheet has been joined on the top of shaft of fan by soft welding technique at low temperature as shown in fig.2 and fig.3 or by drilling technique.

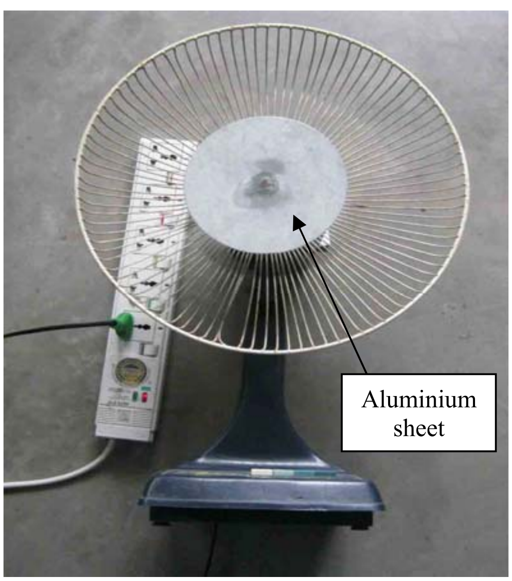

Fig.2: Fan with joined thin aluminium sheet

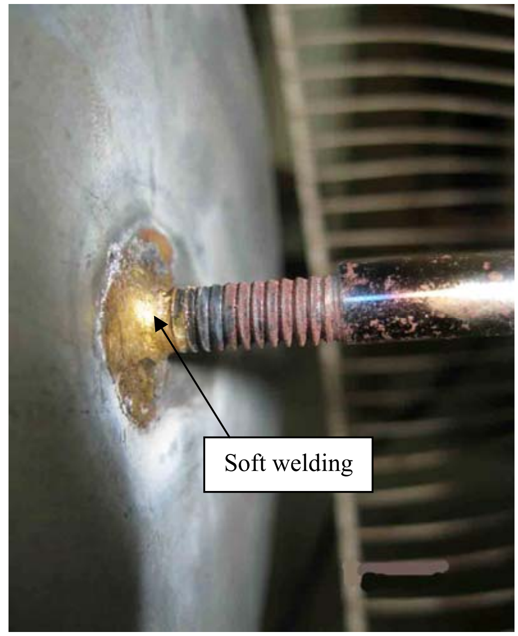

Fig.3: Soft welding of aluminium sheet with shaft

The second technique has been implemented drilling the shaft of a required sized hole on to the shaft of fan. Then another shaft type narrow rod has been pushed and fixed at balanced position. Then another two narrow holes has been bored at two ends of the rod using drilling technique. Another two narrow holes of same size has been bored in the aluminium sheet at proper position. Then using nuts and bolts, the aluminium sheet has been joined with narrow rod so that sheet is attached with the shaft of the fan and rotates uniformly when switched ON of the fan. This proposed experimental set up can be used for depositing a single layer or a multi layer film at low cost.

3. EXPERIMENTAL PROCEDURE

For deposition of semiconductor films on substrate, the fan can be set up at proper position for experiment in such way that the aluminium sheet was aligned horizontally. The substrate on which film will be deposited must be attached on the sheet at middle position for uniformity achievement. After that, chemical of depositing semiconductive material(s) have to put on the substrate.

Fig.4: Cubic glass frame

To observe the experiment properly in close position, a transparent glass (it may be cubic or other types) frame as shown in fig.4 should use to cover the aluminium sheet to rescue from harmful chemical at the time of rotating the shaft. A schematic diagram of the system is shown in fig.5. When the switch of fan will be pressed then due to proper rotation of the shaft, the chemical will spread out uniformly and will be deposited on the substrate. In this way multilayer film can be deposited on a substrate to characterize the properties of film with a view to visible range photon energy (VRPE) for justification of the matching property with VRPE with that of semiconductive material band gap energy. This procedure can be adopted varying and controlling the speed of fan to deposit films successively to get a proper shape for using incipient laboratory test.

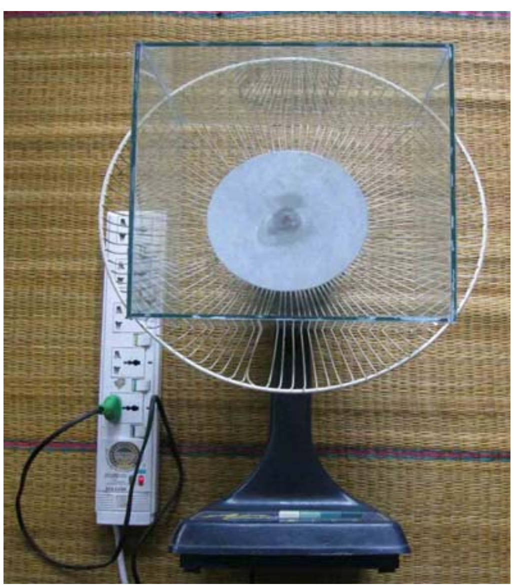

Fig.5: Arrangement of the system

4. RESULT AND DISCUSSION

In result, the aim is to compare between the output of single layer and multilayer films in case of absorption coefficient parameter only. Owing to greater absorption of photons results in increase of absorption coefficient. If the absorption of photons are radiated by sun is increased, then the main target is to generate more electricity by photovoltaic effect will be succeeded.

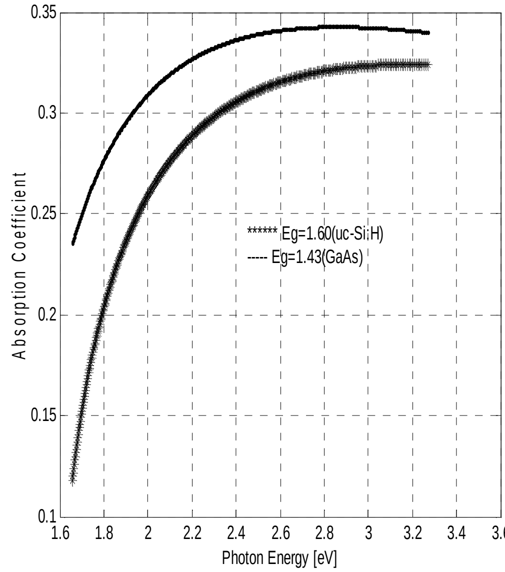

Fig.6: Absorption coefficient vs. Photon energy

Figure6 Shows the absorption coefficient for the case of single larger considering two distinct band gaps energy Eg=1.43(GaAs) and Eg=1.60(μc-Si:H) to compare the band gap matching with visible range photon energy(VRPE). To obtain the fig.6 MATLAB plot has been used for the relation of absorption coefficient and photon energy are given by the following Davies and Mott's generalized equation [12].

$$\alpha = \frac{B(h\upsilon - Eg)}{h\upsilon} \qquad (1)$$

Where α is absorption coefficient, B is transient probability constant has been approximated to 0.82. hυ and Eg are photon energy & semiconductor band gap energy successively. To characterize the constant P, only direct band gap has been taken into account which estimates the value of P is ½.

At lower value of photon energy within visible range, higher band gap causes lower absorption and lower band gap causes higher absorption. But immediately after increasing the photon energy at considerable value, higher band gap semiconductor (μc-Si:H-1.60) gives higher absorption comparatively than that of lower band gap semiconductor (GaAs-1.43) that means photon energy around hυ=1.8eV small increase in photon energy, maximum percentage of absorption is possible for band gap near equal to the corresponding photon energy. Again at higher level of photon energy, fig.6 shows that both of the band gaps result the absorption coefficient is in almost saturation level and going down towards low valued for more higher photon energy relative to the band gap energy. With a view to solving this problem of absorbing photon energy by a single layer, multilayer film has been taken into account whose absorption coefficient-photon energy curve is shown fig.7 also with a single layer film curve for comparing the absorption between them.

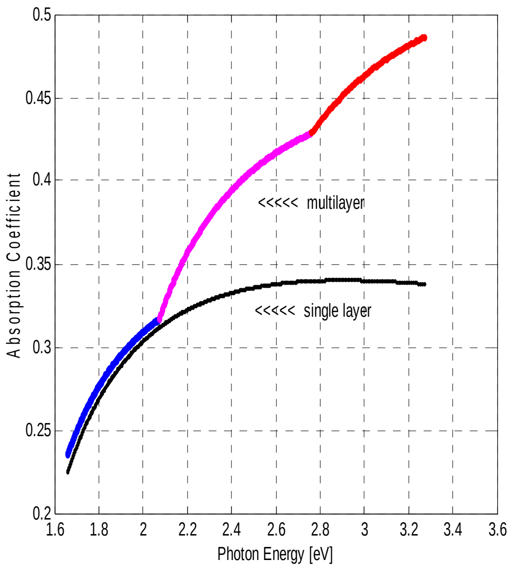

Fig.7: Absorption coefficient vs. Photon energy

In this case also, MATLAB plot has been based characterizing the relation between absorption coefficient and photon energy by following Davies and Mott's generalized equation [12].

$$\alpha = \frac{B(h\nu - Eg)}{h\nu} \qquad (2)$$

If an incident photon has more energy than the band gap, the excess energy will be converted into heat since the electron can only absorb the exact amount of energy required to move to the valence band. Multijunction solar cells can make better use of the solar spectrum by having multiple semiconductor layers with different band gaps. Each layer is made of a different material, which usually is a III-V semiconductor, and absorbs a different portion of the spectrum. The top layer has the largest band gap so that only the most energetic photons are absorbed in this layer but some of these energetic photons still will pass through the top layer those are not trapped by this layer are trapped by the next layer and so on. But in this case, the excess energy will be converted into heat which is less considerable matter than the photon trapping.

Less energetic photons must pass through the top layer since they are not energetic enough to generate electron hole pairs (EHPs) in first layer of the material. Each layer going from the top to the bottom has a smaller band gap than the previous. Therefore, each layer absorbs the photons that have energies greater than the band gap of that layer and less than the band gap of the higher layer. Thus whole of the solar spectrum of the activated range is possible to trap by such kind of multi layer solar cell and absorption coefficient is increased. The most common form of multi-junction solar cell consists of three layers, which is called a triple-junction solar cell.

Figure7 Shows that multilayer film absorbs more photon energy than the single layer film. Because the multilayer, triple layer in this case, the semiconductor of three band gaps have been so chosen that, the VRPE is concisely matched with the band gaps for triple layer. As the photon energy and band gaps are concisely matched, so the higher absorption is obtained than that of single layer semiconductor film.

5. CONCLUSION

In conclusion, we have studied the multilayer film taking into account different band gaps based on different semiconducting materials band gaps approximation and comparison has been done with single layer film on the basis of photon absorption only. Considering the study, programming analysis has been done using MATLAB and shown in fig.6 and fig7. The performances are evaluated using MATLAB program is different in case of practical implementation. But it promises as a candidate for future high performance solar cells. A model has been proposed, can be implemented for deposition of film at low cost and can be evaluated the practical results with programming results and comparison has taken into account between single junction and triple junction cells of efficiency were limited to 24.67% and 37.57% respectively based on In_xGa_{1-x}**N** alloys[10]. By increasing the number of junctions up to infinity, theoretical efficiency is increased to 86.8% [13]. The above figures show that the higher absorption coefficient in case of multilayer film can be implemented for high performance of tandem cells applications and experiment is possible at low cost using the model has been proposed.

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7. NOMENCLATURE

Symbol	Meaning	Unit
Eg	Band gap energy	(eV)
VRPE	Visible range photon energy	(eV)
PV	Photovoltaic	Dimentio-nless
MIS	Metal insulator semiconductor	Dimentio-nless
EHP	Electron hole pair	Dimentio-nless