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Recycling Electrical Energy with the Help of Photovoltaic Setup for Indoors

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Abstract—*Photoelectric effect is the cleanest way to generate electricity. Presently, it is widely used to convert solar energy into electrical. Our approach is that we can use this phenomenon for converting artificial light such as in indoor environment to generate some amount of electricity which can be further used for household purposes. This would help in contributing as a solution to the problem rising electricity needs. It can also be used to solve the most unavoidable problem of Global Warming by providing clean energy and recycling the existing one.*

1. INTRODUCTION

The world today is facing a major problem; that of matching up the electric supply with the electricity needs of the ever rising population. The greatest victims of this problem are countries like India. Population of India in 2013 was 1.252 billion [1], whereas the power production is only 255,013 MW [2]. Most of the households of India face massive power cut problems in summers. The Electricity Act, 2003 allows the private production of electricity by users, which encourages us to write this paper. It will be far easier for the industrial users to generate electricity in comparison with regular households, hence it is advisable for them to reuse or recycle the existing supply–the concept on which our paper is based. About 20 percent of the electrical consumption is used for lightning purposes. It is possible to reuse that electricity with the help of a photovoltaic setup.

In the following sections, we will discuss about the materials, their properties which can be used to generate electricity in various illumination sources such as CFL, LED, etc and their applications in daily lives.

2. WHY PHOTOVOLTAIC CELL?

Biggest advantage of using photovoltaic system is that it is environment friendly. It also has no noise, no emissions, no moving parts and no use of fuel or water in the generation of electricity. It requires minimal maintenance and has a long lifetime (up to 30 years). Electricity can be generated wherever there is light (solar or artificial). Using them indoors can overcome its limitations as a solar cell, which doesn't give any output in night and offers limited productivity in cloudy weather.

3. REQUIREMENTS OF PHOTOVOLTAIC MATERIALS

Photovoltaic material should have certain characteristics which are enumerated below:

Band Gap

The band gap of a material should be compatible with the spectrum of the incident light. Material with large band gap would cause the photons of insufficient energy to pass through the material without creating any electron-hole pair. But, material having small band gap will experience heat dissipation due to excess of energy. Therefore materials having appropriate band gap should be used.

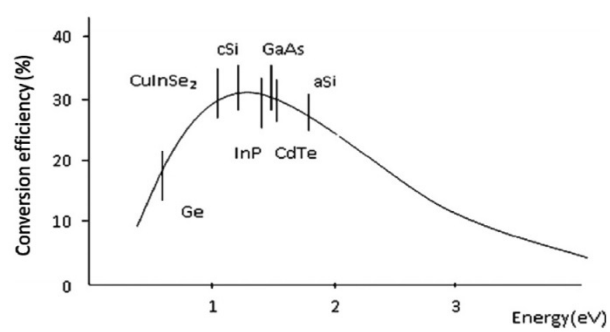

Fig. 1: Band gap dependence of conversion efficiency [10].

Refractive Index

Refractive index of different layers in a solar cell should be nearly equal for obtaining better optical properties.

Absorption Coefficient

Absorption coefficient of a material should be high so that they could easily absorb photons and excite electrons into conduction band. For a thin film photovoltaic cell, a material with good absorption coefficient should be used.

4. MATERIAL SELECTION

Based on Illumination Sources

Photovoltaic cells were conventionally designed for converting solar spectrum into electrical energy. A typical solar cell of area 1m^2 generates 150 W of electrical energy in outdoor environment at noon [3][4]. In the earlier decade incandescent light sources were majorly used, but now the world has switched to fluorescent and LED lamps for energy saving purposes.

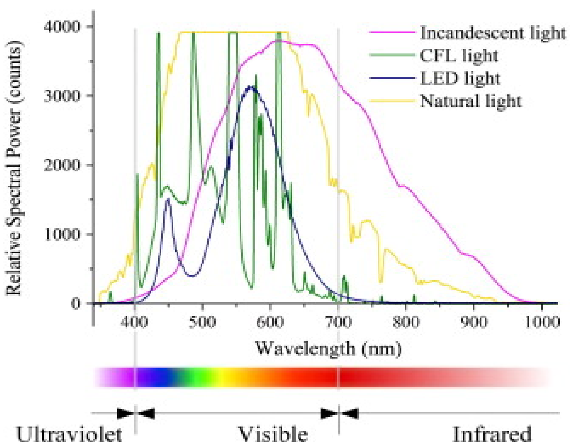

Fig. 2: Wavelength spectra of different indoor light sources compared with natural light.

The above Fig. is obtained from [5], they measured the spectral distribution of each light sources using a spectrometer. It is clear from the image that a spectrum of incandescent light is wider than that of fluorescent and LED lights. Spectral component of incident light is a key factor on which output power density of solar cell depends. Due to this factor, we have to select an appropriate solar panel for maximum efficiency for indoor environment.

Table 1: Maximal efficiency values for crystalline silicon, amorphous silicon and organic BHJ photovoltaic cells under different spectral illumination [6].

		Luminous Source			
		Solar	**CFL**	**CCFL**	**LED**
PV Material	Crystalline-Si	49%	50%	52%	54%
	Amorphous-Si	37%	74%	70%	80%
	OPV	28%	63%	59%	63%

From the above given table, we deduce that amorphous silicon and organic bulk heterojunction would perform well under fluorescent and LED spectra relative to crystalline silicon due to their strong absorptivity and good carrier separation.

Antireflection Coating (ARC)

A large part of long wavelength incident photons are reflected back and not absorbed, which reduces the efficiency of the photovoltaic cell. ARC is used to reduce the reflection from the surface of the cell. It is based on the destructive interference at the interface. ARC allows only less than 1% of incident light to reflect back [7]. It consists of a layer of a dielectric material deposited on active material surface of the PV cell. Thickness of this layer is given by $d=\lambda/4n$, where d is thickness, λ is wavelength of incident light and n is refractive index. Usually AR coatings are made of MgF_2, as it is hard and durable coating, which reduces the reflection and increases the absorption [9].

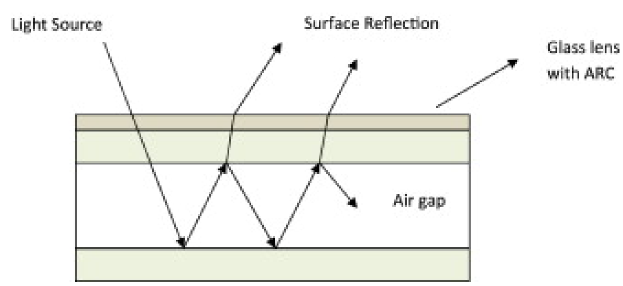

Fig. 3: Wavelength spectra of different indoor light sources compared with natural light [8].

Absorber Material Thickness

The efficiency of photovoltaic cell is intensely affected by the thickness of absorber material. Thickness of absorber material depends on absorption coefficient of materials and wavelength of absorbed photons. Due to insufficient thickness, surplus energy of photons having energy higher than the band gap and energy of photons having energy lower than the band gap are wasted which results in loss of radiation. Absorption coefficient should be nearly equal to the absorption length or photon wavelength in order to achieve maximum absorption. The thickness of absorber material for zero transmission loss, d is given as $d = 1/\alpha(E_g)$, where $\alpha(E_g)$ is the absorption coefficient of photon of energy Eg [11,12].

5. APPLICATIONS

This setup can be used in residential houses, hotels, malls, offices and many other places where electricity is used for lighting purposes. The energy recycled using this setup can be used for many purposes such as charging a mobile phone, charging AA batteries, charging inverter batteries, backup in case of power cuts and other household uses.

6. CONCLUSION

Through this paper, owing to the urgent need to recycle electrical energy, we have concluded that such electrical energy could be recycled using photovoltaic setups in indoor environment. Indoor environment will cause full utilization of a photovoltaic cell as compared to a solar cell. Furthermore, using photovoltaic cells of special material such as Amorphous-Silicon coated with Anti-reflection coating and of proper thickness can help in achieving a proper solution to the problems of Global Warming and power demands of the ever rising population.

7. ACKNOWLEDGEMENT

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