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ENERGY HARVESTING FROM SOLAR CELLS UNDER THE TYPICAL ILLUMINATION TYPES ENCOUNTERED IN BUILDINGS

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Abstract— **Energy harvesting powered devices have the potential for widespread use in buildings. The most prevalent ambient energy source available in buildings is light, which is normally harvested using photovoltaic devices. The light to be harvested can be from both natural and artificial sources and a range of different types of solar cells are available to suit differing light sources and intensities, and as such must be selected to suit the type of light to be encountered. For use inside buildings it is desirable to choose a device which will operate efficiently under artificial lighting as many locations have limited or no natural light, however, the nature of artificial sources is changing over time from incandescent sources, through fluorescent lights, with LED lights currently attracting significant interest due to energy savings. This paper presents an investigation into the selection of solar cell type for a range of artificial lighting sources and illumination levels.**

I. INTRODUCTION

ENERGY harvesting powered devices have the potential for widespread use in buildings. For battery powered installations, harvesters offer more environmentally friendly solutions and do not need periodic replacement since long lifetimes can be achieved [1]. When natural solar energy is not available, harvesters must rely on artificial sources. However, artificial sources are evolving from incandescent, through fluorescent, to LED in future which is attracting significant interest due to energy savings. An investigation of the difference in the energy harvested, caused by changing the artificial source, has not been presented in previous research.

This paper reports an investigation of the output power achievable from 4 types of solar cell (detailed in table 1) under 3 different artificial light sources, typically encountered within buildings, for various illumination levels.

Table 1. Details of the selected solar cells including the use that each one is optimized for

Model	Material	Use	Manufacturer
MC-SP0.8	Polycrystalline Silicon	Outdoor	Multicomp
AM-1815	Amorphous Silicon	Indoor	SANYO
AM-5608	Amorphous Silicon	Outdoor	SANYO
Indy4050	Dye-Sensitized	Flexible	G24i

Of major importance to energy harvesting powered devices is that the solar harvester selected will harvest sufficient energy when deployed irrespective of the light source providing the illumination.

Many different solar cell technologies [2, 3] have been developed and optimized for energy harvesting from either natural or artificial light [4]; the output power of a solar cell is influenced by the spectral composition of the incident light. Therefore, for example, the output power of an outdoor type solar cell can decrease dramatically when the light source is changed from natural to artificial due to the differing spectra. Energy harvesting powered devices will not operate if the solar cell cannot harvest sufficient energy [5], which may occur if the solar cell is optimized for a different light source. Therefore this paper investigates the difference in output power of solar cells under different light sources and aims to aid the selection of devices deployed in buildings.

The 4 different types of solar cell were selected because they represent the main types available. Three important light sources were tested: incandescent (halogen), compact fluorescent lamp (CFL) and LED.

II. EXPERIMENTAL PROCEDURE

In this paper, each light source is investigated at 3 levels: 1000 lx representing well illuminated conditions; 500 lx as the normal lighting condition at the desk surface; and 200 lx representing poor lighting. The investigation was performed in an opaque enclosure to shield the solar cell from ambient light. The light source was mounted inside the enclosure with a filter to change the incident light level on the solar cells which were situated at the center of the illumination. The incident light level on the device under test was measured using a light meter (ISO-TECH Lux-1337), and adjusted to the desired value. The solar cell output was loaded using a resistance box and its output power calculated. The Maximum Power Point (MPP) [6] of the solar cells were then found by varying the load.

III. RESULTS

The power densities of the solar cells at their MPP are shown in table 2 for the incandescent light source, table 3 for the fluorescent light source, and table 4 for the LED light source.

Table 2. Maximum output power densities of solar cells under the incandescent light source

Incandescent Source	Power Density ($\mu W \cdot cm^{-2}$)		
	1000 lx	500 lx	200 lx
MC-SP0.8	566	194	101
AM-1815	38	14	5
AM-5608	72	19	6
Indy4050	24	9	5

Table 3. Maximum output power densities of solar cells under the fluorescent light source

Fluorescent Source	Power Density (μW·cm^{-2})		
	1000 lx	500 lx	200 lx
MC-SP0.8	30	12	3
AM-1815	37	18	4
AM-5608	37	17	4
Indy4050	13	8	3

Table 4. Maximum output power densities of solar cells under the LED light source

LED Source	Power Density (μW·cm^{-2})		
	1000 lx	500 lx	200 lx
MC-SP0.8	25	8	3
AM-1815	27	10	3
AM-5608	29	10	4
Indy4050	19	7	2

The output power of the AM-1815 decreases when the light source changes from incandescent to CFL (7 % reduction) and LED (28 % reduction). The other types have a larger reduction in output power, especially the MC-SP0.8, under CFL (95 % reduction) and LED (96 % reduction). The flexible solar cell has an average 60 % less power than the other devices in all situations. The output of the MC-SP0.8 under each light source at 500 lx is shown in Fig. 1; a significant difference (~20 times) occurs between the power density under incandescent and CFL/LED illumination sources.

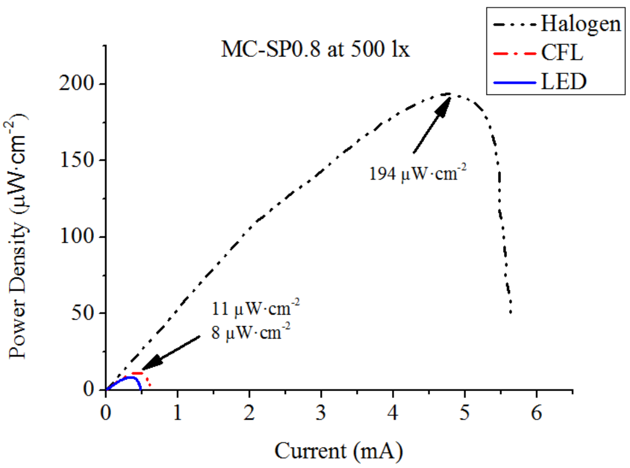

Fig. 1. Power density versus current for MC-SP0.8 solar cell harvesting energy from different light sources at 500 lx

The AM-1815 has similar performance when used under incandescent, CFL or LED at 500 lx, as shown in Fig. 2, which suggests that this device is most suited for use with a range of light sources.

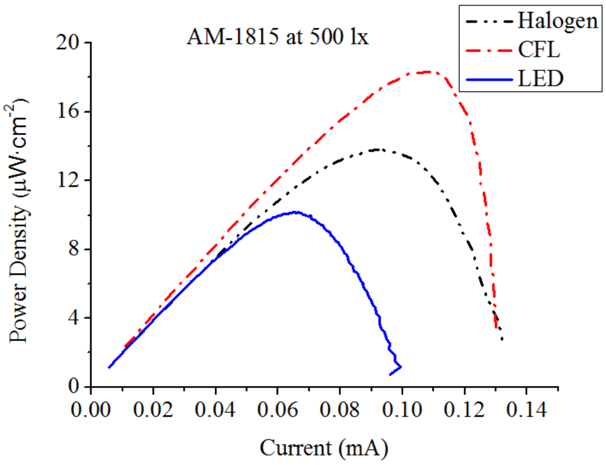

Fig. 2. Power density versus current for AM-1815 solar cell harvesting energy from different light sources at 500 lx

IV. CONCLUSIONS

In conclusion, the solar cells generally harvest less power under LED than halogen and CFL light sources. The large difference in output power of the natural light solar cell between incandescent and CFL/LED sources could lead to a device which can only operate under incandescent lighting. The amorphous-Si solar cells show a similar power output under all three sources. The flexible solar cell harvests least solar energy in all situations but is necessary for mounting onto curved-surfaces.

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