Abstract

In present work a compound holographic system consisting of a diffraction grating and a holographic lens has been fabricated to disperse and focus different portion of solar spectrum on laterally arranged solar cells of different band gaps to achieve maximum efficiency operation. Such concentrators are light–weight, low-cost and do not require tedious processing for their mass production.

Key words: Dispersive concentrating system, Compound holographic optical Element, Holographic concentrator, Diffractive optical system

Introduction

To reduce the cost of solar photovoltaic power generation use of concentrators is an attractive proposition. This scheme replaces costly solar cell area with relatively low-cost smaller concentrator area still achieving same out-put power. However, such concentrators concentrate the entire solar spectrum on cells. The portion of solar radiation which does not match the band gap of solar cells degrades the absorber material by overheating. This also leads to fall in efficiency of performance of solar cells. To get rid of absorption of unwanted portion of solar spectrum, spectral splitting and their concentration on laterally arranged multiple band gap solar cells has been
proposed and are being extensively investigated both using conventional optical elements and holographic optical elements [1-9].

In present work a compound holographic optical element system consisting of holographic grating and a holographic lens has been fabricated on a single high resolution holographic plate (PFG01). Spectrum of white light diffracted through recorded compound system has been presented. To show the effectiveness of such system in laterally arranged solar cells of different band gap a laboratory test was carried out by concentrating different portion of solar spectrum on a photocell. Stopping potential was measured for spectrum of different wavelengths (frequencies) so as to determine Planks constant (h).

2. Recording and play back geometry of compound holographic optical element system

Recording of interference pattern generated due to coherent superposition of a spherical wave coming out of a point source and a plane wave front gives rise to an off axis zone plate which is regarded as a holographic lens(10-11). Whereas, holographic grating is recording of interference pattern of two coherent plane waves in a high resolution recording medium. (12-13)

For recording compact dispersing concentrating holographic system a high resolution silver halide film was exposed to resulting interference pattern of coherent superposition of two plane wave fronts to record a grating in first exposure using experimental setup as shown in figure 1. Second exposure was made on the same film at the same location where plane wave front remained the same as before but collimating lens from one of the path was removed from object beam to make object beam a spherical wave front as shown in Figure-2. The doubly exposed recording plate was processed using reversal bleach method [14] to get the compound system.

![Fig.1- Schematic of the geometry for recording Holographic grating during first exposure](image-url)
**Experimental:**
The recorded compound system was played back using mercury vapor lamp to show effectiveness of spectrum splitting and its concentration (fig3). Figure 4 shows spectrum of mercury vapor lamp diffracted through a holographic lens. Figure 5 shows spatially separated focused line spectrum when mercury light passes through the compound holographic system consisting of a grating and a lens.
Figure 4 spectrum of mercury vapor lamp diffracted through a holographic lens.

Figure 5 spatially separated focused line spectrum obtained from a stacking of conventional grating and a conventional conversing lens

Result and Discussions
Focused spatially separated line spectrum was further used in photoelectric effect experiment to obtain stopping potentials of target material (cesium) of the photocell at different optical frequency. Values of stopping potentials at different wavelengths were used to find value of Plank’s constant. Table 1.Presents stopping potential of target material at different frequencies.
### Compound Holographic Optical Element System

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Colour of spectrum</th>
<th>Frequency in Hz</th>
<th>Stopping potential in Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Violet ($\nu_1$)</td>
<td>$7.14 \times 10^{14}$</td>
<td>1.164</td>
</tr>
<tr>
<td>3</td>
<td>Blue ($\nu_2$)</td>
<td>$6.88 \times 10^{14}$</td>
<td>0.950</td>
</tr>
<tr>
<td>4</td>
<td>Green ($\nu_3$)</td>
<td>$5.49 \times 10^{14}$</td>
<td>0.373</td>
</tr>
<tr>
<td>5</td>
<td>Yellow ($\nu_4$)</td>
<td>$5.19 \times 10^{14}$</td>
<td>0.248</td>
</tr>
</tbody>
</table>

From Einstein Photoelectric equation

\[ h\nu_1 = h\nu_0 + eV_1 \]  \hspace{1cm} (1)
\[ h\nu_2 = h\nu_0 + eV_2 \]  \hspace{1cm} (2)
\[ h\nu_3 = h\nu_0 + eV_3 \]  \hspace{1cm} (3)
\[ h\nu_4 = h\nu_0 + eV_4 \]  \hspace{1cm} (4)

From equation(1) and equation(2)

\[ h(\nu_1 - \nu_2) = e(V_1 - V_2) \]

does not work as an answer.

\[ h = \frac{e(V_1 - V_2)}{\nu_1 - \nu_2} \]

Also,

\[ h = \frac{e(V_3 - V_4)}{\nu_3 - \nu_4} \]

Calculated value of $h$ was found to be $6.46 \times 10^{-34} \text{ J-Sec.}$

**Conclusion**

The present investigation shows that such light weight, low cost holographic system can advantageously used for laterally arranged solar cells of matched band gap to get appreciable efficiency of solar photovoltaic power generation.

**References:**


