Spectrally selective flat reflective lenses for photovoltaic applications

Sergiy Valyukh

Laboratory of Applied Optics, Department of Physics, Chemistry and Biology, Linköping University, SE-581 83 Linköping, Sweden

Many techniques for light trapping in photovoltaic cells and for concentration of sunlight onto the active layers are applied to increase efficiency of photovoltaic systems and to decrease their costs. However, this leads often to temperature increase of the photovoltaic material that, in turn, has a detrimental effect on the energy conversion efficiency and life time of the photovoltaic cell [1]. The main reason of the temperature increase is the absorption of the incoming sunlight within spectral range that is not converted into electrical energy. The situation can be improved dramatically by the use of reflectors and lenses with selective spectral properties. For practical applications, these reflectors and lenses are desired to be flat and thin. The goal of the present work is to present such reflective lenses.

The proposed spectrally selective reflective lenses are based on volume Bragg gratings (Fig 1). In contrast to numerous selective reflectors utilizing coatings, these reflectors do not absorb the light. The light of the “needed” spectral range is reflected to the active material, whereas the rest light passes through the grating without absorption. In opposite to the volume Bragg gratings utilised in many applications (usually lasers), the spectrum of the reflected light from the lenses proposed by us is relatively broad. One way of realization of such reflective lenses is to use a cholesteric liquid crystal (ChLC) polymer. The broad spectral band is achieved due to the high birefringence and the pitch deviations. The high reflectance (close to 100%) can be obtained owing to two layers of ChLC polymers with opposite handedness. The lens effect is accomplished because the orientations of the helical axes of the ChLC vary in space and these axes are not strictly linear. The desired distribution of the helical axes is achieved due to non-uniform alignment conditions in the ChLC cell before polymerisation.

Figure 1 shows the distribution of the calculated electromagnetic field reflected from the structure presented in Fig.1. The incident light has a plane wavefront, whereas the wavefront of the reflected light is spherical that is inherent to a lens.

As one of the examples of practical implementation, we are going to demonstrate how the proposed reflective lenses can increase efficiency of the folded PV cells [2].

References