Exploration for 2-Dimensional PhotoRecepto-Conversion Scheme (2DPRCS) Based on Polydimethylsiloxane(PDMS)

Hokkaido Univ. , Nanostructure Physics Lab. , Yubo Wang , Xingbai Hong , Akira Ishibashi

E-mail: wang.yubo@es.hokudai.ac.jp

1. Introduction

So far, many studies have been done in order to improve the efficiency of solar cells, and numerous types of photovoltaic devices have been reported. However, it is still difficult for us to convert the full sunlight spectrum into electricity. In order to solve this problem, we have proposed a new structure that is of potential interest for the development of solar cells industry and greatly improve the efficiency of solar cells. Different from the conventional solar cells in which photons and photocarrier are absorbed parallelly, our new approach is that we make the photon and photocarrier absorbed orthogonally. The conventional solar cells suffer greatly from the light absorption and photo-generated carrier collection, in our proposal, the multi-striped orthogonal photon-photocarrier propagation solar cells can absorb more photons, meanwhile, the loss of photocarriers would be less. In our asymmetric waveguide coupled concentrating solar cells, how to make spatially propagating light efficiently convert into wave light is of vital importance for the research. The 2DPRC is composed of redirection waveguide (RWG) that consists of photo-propagation direction converter (PDC), discrete translational symmetry waveguide (DTSWG), and a planar (2D) waveguide. We have found that the space inversion (left and right) in symmetric structure, coupled with time-reversal symmetry, light that has been convert to two-dimensional from three dimensions will go back to three dimensions. In this case, we assume that if we use asymmetric waveguide, the problem will be solved. The waveguide we proposed is asymmetric to achieve better confinement of photons in the waveguide resulting in more photon harvesting.

2. Experimental Results and Simulation

Here we propose a new type of waveguide that achieves total reflection before two interfaces by filling two non-concentric semicircles with media of different refractive indices. We first simulated the light incident at different angles manually by rough modeling, and then accurately by software, and we found that the results were very similar for several sets of data, as is shown in Fig.1. Finally, we can believe that the reflection angle of light incident on the outer circle must be greater than the angle of incidence, and this leads to the conclusion that if light is incident at a critical angle, all light will not be able to escape from the waveguide. In addition, we propose a simple device to measure the refractive index of the sample, and after several experiments, the error is within the acceptable range. We have also measured how the variation of waveguide length affects the laser intensity using our homemade PDMS. What's more, the progress has been made in the loss of light through the waveguide path and the ability to change the direction of light when the waveguide path is bent.

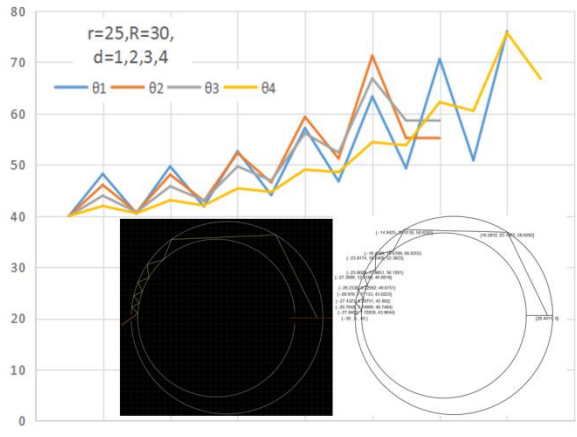

Fig. 1 The graph shows the relationship between the distance between the path of the light and the center of the circle after incidence. Bottom left is rough simulation while bottom right is software programming simulation after light incident on the waveguide with r=25, R=30, d=3, θ= 40°.

3. Conclusion

We have proposed a system with 2D PhotoRecepto-Conversion (2DPRC) scheme using cylindrical surface. We expect the light-wave merging can be fulfilled in the PDMS waveguide with the discrete translational symmetry. The new waveguide with the discrete translational symmetry would serve, in near future, as a key component for excellent concentration photovoltaic systems with high conversion efficiencies.

Reference

[1] A. Ishibashi, Y. Okura, and N. Sawamura, *Energies* 2020, 13, 5234; doi:10.3390/en13195234