Light Management Toward Efficient Organic Solar Cells

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Abstract: Light management methods for organic solar cells (OSCs) are presented: (i) thin-film optic method utilizing the inherent asymmetry of semitransparent OSCs; (ii) V-groove-based light-trapping structure as an effective means to enhance the efficiency of OSCs.

OCIS codes: (350.6050) Solar energy; (310.6845) Thin-film devices

1. Description of main ideas and results

Organic solar cells (OSCs) are regarded as a next-generation photovoltaic (PV) technology with various form-factor advantages such as flexibility, light weight, and optional semi-transparency. Expectations for deployment in real-world products are growing fast with recent development of OSCs with efficiency higher than 10%. As with other solar cells, further improvement in efficiency and development of low-cost fabrication method/ differentiating features are essential in enhancing the practical viability to its full potential. In this work, examples of light management methods are introduced as an important way to improve the power conversion efficiency (PCE) of OSCs.

First, optical optimization method based on multilayer thin-film optics is briefly described using transfer-matrix formalism [1]. It is then used to maximize the efficiency of semitransparent OSCs that exhibit PCE typically less than half of the opaque counterpart [2]. Optical asymmetry inherent to multilayer thin films containing a thin metal layer is utilized to realize semitransparent OSCs with the PCE corresponding to approx. 85% of that of opaque control cells. Overall approach is summarized in Fig. 1.

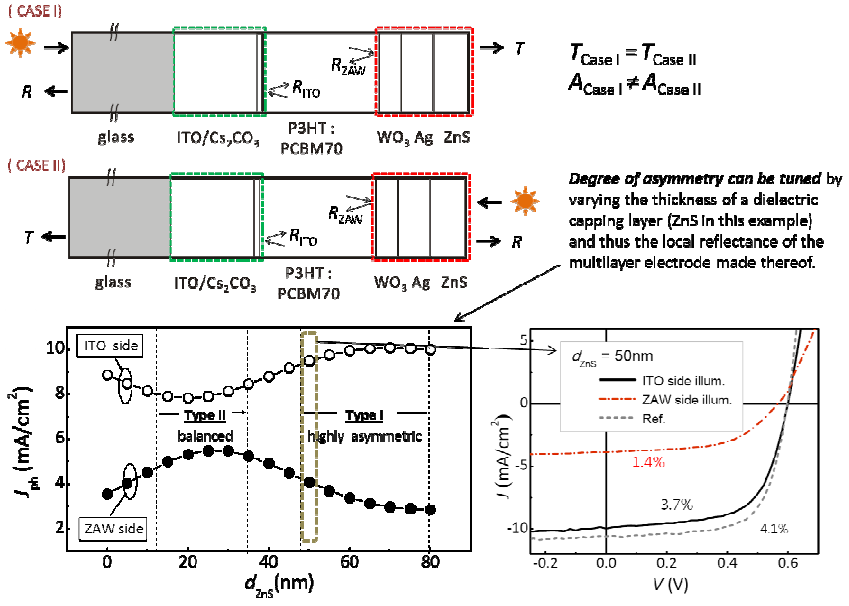

Fig. 1. Overall optimization method for semitransparent organic solar cells utilizing the inherent absorption asymmetry and experimental results [2]

In the second part, a V-groove array film is explored as an effective external light-trapping structure to enhance the PCE of OSCs without causing complications in electrical properties [3]. (See Fig. 2 for details.) A combinatorial analysis based on both geometrical and thin-film wave optics is compared with the experimental results in various aspects.

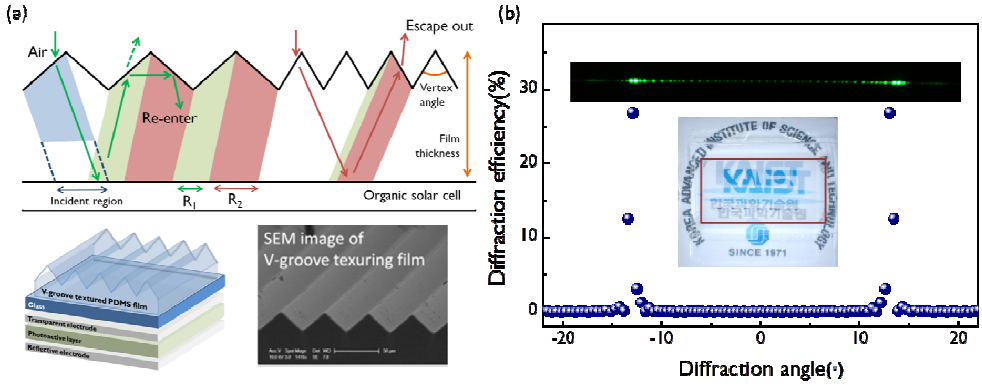

Fig. 2. (a) Operational principle of V-groove array as an external light-trapping structure (b) Diffraction of a light after passing through the fabricated V-groove film. (Peaks correspond to zero diffraction orders due to geometrical splitting of incident light. Shown in the graph is the calculation result obtained with DiffractMode™.) [3]

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3. References

[1] S. Han, S. Lim, H. Kim, H. Cho, and S. Yoo, "Versatile multilayer transparent electrodes for ITO-free and flexible organic solar cells," IEEE J. Sel. Topics in Quant. Elect. **16** (6) 1656-1664 (2010)

[2] D. Han, H. Kim, S. Lee, M. Seo, and S. Yoo, "Realization of efficient semitransparent organic photovoltaic cells with metallic top electrodes: utilizing the tunable absorption asymmetry," Optics Express, **18** (104), A513-A521 (2010)

[3] C. Cho, H. Kim, S. Jeong, S-W. Baek, J.-W. Seo, D. Han, K. Kim, Y. Park, S. Yoo, J. Lee, "Random and V-groove texturing for efficient light trapping in organic photovoltaic cells," Sol. Mat. Sol. Cells **115**, 36-41 (2013).