Performance Optimization of Solution Processable Solar Cell based on Binary Blends of Liquid-Crystalline Phthalocyanines

M. Ozaki,†,∗ H. Fukui,† S. Nakano,† T. Saito,† S. Ikehara,† M. Ohmori,† Q.-D. Dao,† T. Kamikado,† M. Yoneya,∗ Y. Shimizu,∗ and A. Fujii†

1 Graduate School of Engineering, Osaka University, Yamada-oka, Suita, Osaka 565-0871, Japan
2 Nanosystem Research Institute, AIST, Umezono, Tsukuba 305-8568, Japan
3 Research Institute for Ubiquitous Energy Devices, Kansai Center, AIST, Ikeda, Osaka 563-8577, Japan

Low cost and high efficient solar cell has earnestly been desired for a sustainable world. The use of self-assembling characteristics is one of the most potential candidates for the realization of a prevailing solar cell. We have demonstrated a high-efficient bulk-heterojunction (BHJ) solar cell [1] based on a mesogenic phthalocyanine (Pc) derivative, 1,4,8,11,15,18,22,25-octaheptylphthalocyanine (C6PcH2) exhibiting a high carrier drift mobility in excess of 1 cm²/Vs [2]. The device can be fabricated through a spin-coating process from the solution of C6PcH2 and 1-(3-methoxy-carbonyl)-propyl-1-1-phenyl-(6,6) C61 (PCBM). For the formation of the optimally phase-separated nano-structure for efficient carrier generation and transportation, the mesogenic properties should play an important role. By inserting appropriate buffer layers between the electrodes and active layer and by incorporating additives such as 1,8-diiodooctane (DIO) into active layer for morphorogy optimization, the fill factor FF and energy conversion efficiency were improved to be 0.55 and 4.2%, respectively [3].

As a donor material in the BHJ solar cell, we used a binary blend of CnPcH2 derivatives and investigated a device performance upon changing a ratio of components in the blend. Figure shows J-V characteristics of the BHJ solar cell based on blend of C5PcH2 and C6PcH2 as a function of the concentration of C5PcH2 in the blend donor. The highest power conversion efficiency was demonstrated in a C5PcH2 concentration of 25mol%, which exceeded those of solar cells utilizing pure Pc of C5PcH2 or C6PcH2 as a donor material. This result indicates a possibility of the device performance optimization of the solar cell upon using a blend of liquid-crystalline semiconductors as a material of active layer, as the same manner as the LC blends for the optimization of LCD performance. The blends composed of Pcs with alkylthio-substituents were also used for tuning the electronic properties.

Figure: Current density-voltage characteristics in ITO/PEDOT:PSS/C5PcH2:C6PcH2:PCBM/Al solar cells under the AM 1.5G (100 mW/cm²) solar-illuminated condition as a function of the concentration of C5PcH2 in a binary blend donor of C5PcH2 and C6PcH2.

References:


∗ presenting author; E-mail: ozaki@eei.eng.osaka-u.ac.jp