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Efficient Organic *p-i-n* Solar Cells Having Very Thick Codeposited *i*-layer Using Seven-nine Purified Fullerene

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In 1991, we proposed *p-i-n* organic solar cells in which the *i* interlayer is a codeposited film of organic semiconductors.[1,2] Recently, we reported *p-i-n* organic solar cells in which the *i* interlayer is nano-structure-optimized codeposited film of fullerene (C_{60}) and metal-free phthalocyanine (H_2Pc).[3] At that time, thickness of C_{60}:H_2Pc codeposited interlayer was limited below 180 nm since the photovoltaic performances, especially, the fill factor (FF) of *p-i-n* cells having thicker codeposited films were seriously decreased. As a result, photo-electric conversion efficiency did not exceed 2.5% since the large part of illuminated solar light could not be utilized by such thin photocarrier generation layer.

In the present study, we made seven-nine (99.99999%, 7N) C_{60} samples by single-crystal formed sublimation under 1 atm N_2 (Fig. 1). 7N-C_{60} was incorporated into *i*-layer of *p-i-n* cells (Fig. 2). Figure 3(a) shows the dependence of fill factor (FF) on the thickness of C_{60}:H_2Pc codeposited *i* layer. Surprisingly, FF hardly decreased even for the very thick *i*-layer reaching 1200 nm. Very efficient transport of photogenerated carriers seems to be realized in the present C_{60}:H_2Pc layer using highly purified C_{60}. Simultaneously, short-circuit photocurrent density (J_{sc}) increased with increasing the thickness of *i*-layer (Fig. 3(b)). Figure 4 shows the current-voltage (J-V) cha-

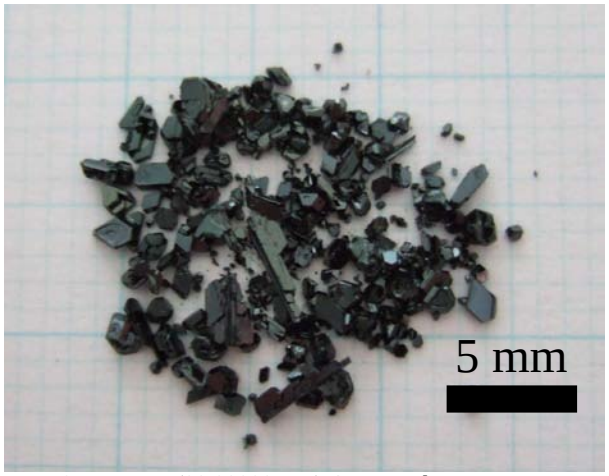


Fig. 1 Seven-nine (99.99999; 7N) C_{60} crystals.

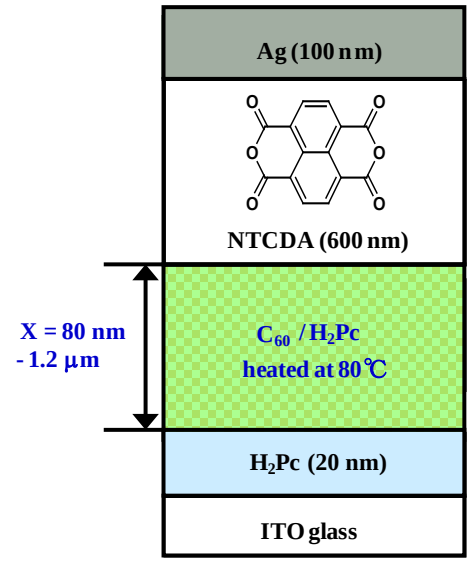
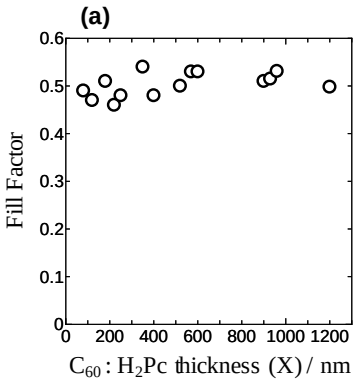


Fig. 2 Structure of p-i-n cell.



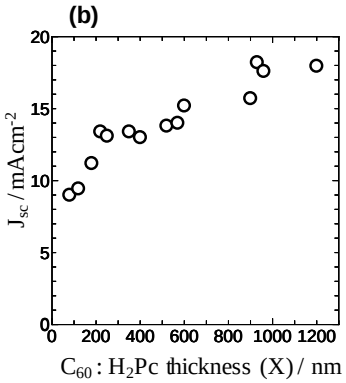


Fig. 3 Dependence of fill factor (FF) (a) and short-circuit photocurrent density (b) (J_{sc}) on the thickness of C_{60}:H_2Pc codeposited *i* layer.

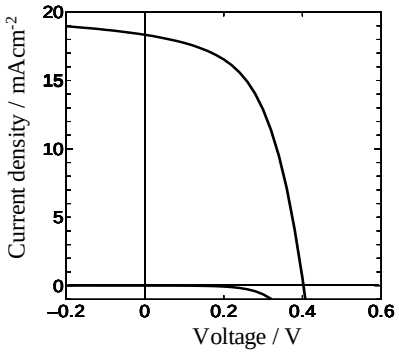


Fig. 4 Current-voltage characteristics for *p-i-n* cell having 960 nm thick *i*-layer. J_{sc}: 18.3 $mAcm^{-2}$, Voc: 0.40 V, FF: 0.53, efficiency: 5.3%.

racteristics for *p-i-n* cell having 960 nm thick *i*-layer. J_{sc} of 18.3 $mAcm^{-2}$ and photo-electric conversion efficiency of 5.3% was observed. Very large photocurrent density is mainly due to nearly 100% utilization of solar light in the visible region by thick *i*-layer.

References

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3) K. Suemori, T. Miyata, M. Yokoyama, M. Hiramoto, *Appl. Phys. Lett.*, **86**, 063509 (2005).

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