29a-G18-9

Plasma Synthesis of Silicon Nanocrystals and Application to Hybrid Si-nanocrystal/P3HT Solar Cells

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Silicon nanocrystals (SiNCs) have drawn extensive attention recently as it has several novel properties mainly resulting from quantum confinement, such as, tunable optical emission and absorption features, and so on [1,2]. This makes it attractive for device applications including light emitting diode, solar cells, etc. [3,4]. Different forms of silicon nanocrystals have been developed to meet the requirements of the vast application fields. Among them, freestanding silicon particles can form inks allowing for solution processing, which is seen as a promising route to reducing the cost of the semiconductor device manufacturing.

In this work, freestanding SiNCs were synthesized from silicon tetrachloride ($SiCl_4$) by using non-thermal VHF (70 MHz) plasma. It is worth to mention that $SiCl_4$, instead of silane (SiH_4), was employed as the precursor because it is safer and cheaper. As-produced SiNCs has a narrow size distribution, and it was successfully employed in hybrid SiNC/P3HT solar cells. Figure 1 shows the solar cell structure. PEDOT:PSS was spin-coated on patterned ITO glass as hole transporting layer. In sequence, SiNC/P3HT blends with different SiNCs mass fractions were spin-coated on it as active layer, and finally, aluminum electrode was evaporated on the top. Device has a well defined active area of 0.046 cm^2. Figure 2 shows the *J-V* curves of devices with different SiNCs mass fraction. AM1.5 solar simulator was employed as the illumination source. Device short circuit current (J_{sc}) increase almost monotonously with SiNCs mass fraction, on the other hand, open circuit voltage (V_{oc}) increases firstly and then decreases after reaching its maximum. As a result, device shows its maximum efficiency of 0.15% when the SiNCs mass fraction is 47 wt%. It indicates that our SiNCs may be a good candidate for future hybrid solar cells.

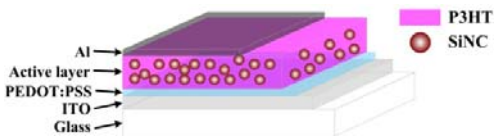

Fig. 1. Solar cell structure with SiNCs.

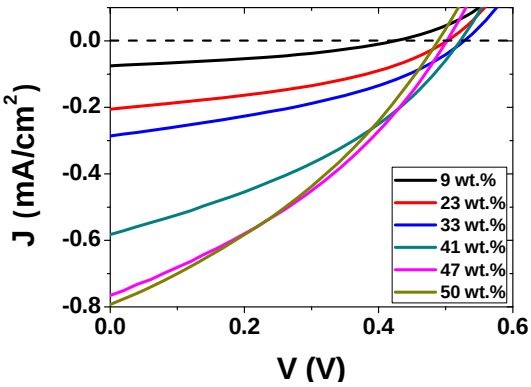

Fig. 2. Photo *J-V* curves of devices with different SiNCs mass fractions.

Acknowledgements: This project is supported by the Funding Program for Next Generation World-Leading Researchers (GR040).

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