

Carbon nanotubes and graphene for transparent electrode and electron-blocking layer of solar cells

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A film of single-walled carbon nanotubes (SWNTs) and graphene can be a dual-functional layer as electron-blocking layer and transparent electrode in various solar cells. We have demonstrated efficient SWNT/Si solar cells using dry-deposited high-quality SWNTs and honeycomb-structured SWNTs [1-3]. Adequately doped mm scale single crystal graphene [4] also exhibited the similar performance. The dual functionality is demonstrated for organic thin film and perovskite solar cells. For organic solar cells, the SWNT/MoOx/PEDOT:PSS layer was demonstrated as a dual functional layer replacing ITO and organic electron-blocking-layer. By replacing ITO, the flexible device can be easily demonstrated [5]. Similar replacement of ITO was demonstrate for Perovskite type solar cells [6]. On the other hand, it is also possible to replace electron-blocking layer and metal electrode for both organic [7] and Perovskite solar cells [8]. This design is promising for low cost device fabrication and semi-transparent solar cells.

References:

- [1] K. Cui, T. Chiba, S. Omiya, T. Thurakitseree, P. Zhao, S. Fujii, H. Kataura, E. Einarsson, S. Chiashi, S. Maruyama, *J. Phys. Chem. Lett.*, 4 (2013), 2571.
- [2] K. Cui, A. S. Anisimov, T. Chiba, S. Fujii, H. Kataura, A. G. Nasibulin, S. Chiashi, E. I. Kauppinen, S. Maruyama, *J. Mater. Chem. A*, 2 (2014) 11311.
- [3] K. Cui, S. Maruyama, *IEEE Nanotechnology Magazine*, 10 (2016) 34.
- [4] X. Chen, P. Zhao, R. Xiang, S. Kim, J. Cha, S. Chiashi, S. Maruyama, *Carbon*, 94 (2015) 810.
- [5] I. Jeon, K. Cui, T. Chiba, A. Anisimov, A. Nasibulin, E. Kauppinen, S. Maruyama, Y. Matsuo, *J. Am. Chem. Soc.*, 137 (2015) 7982.
- [6] I. Jeon, T. Chiba, C. Delacou, Y. Guo, A. Kaskela, O. Reynaud, E. I. Kauppinen, S. Maruyama, Y. Matsuo, *Nano Lett.*, 15 (2015) 6665.
- [7] I. Jeon, C. Delacou, A. Kaskela, E. I. Kauppinen, S. Maruyama, Y. Matsuo, *Sci. Rep.*, (2016), in press.
- [8] T. Chiba, T. Sakaguchi, A. G. Nasibulin, E. I. Kauppinen, R. Xiang, S. Chiashi, S. Maruyama, to be submitted.