

Flexible, Transparent, and Metal-Free Single-Walled Carbon Nanotube Field-Effect Transistors

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With the recent development of novel electronic devices there is a desire for flexible, transparent, high-performance field-effect transistors (FETs). A single-walled carbon nanotube (SWNT) is a strong candidate for realizing such next-generation devices due to their mechanical robustness and excellent electrical properties.

Based on our unique patterned-growth technique using a self-assembled monolayer (SAM) [1], we have reported that high-performance FETs can be easily fabricated using as-grown SWNTs for the channel as well as both source and drain electrodes [2]. Such "all-SWNT" devices are expected to work on flexible substrates without degradation of electrical properties, and may contribute to realization of sustainable development because of metal-free electronics.

In this study, we fabricated flexible, transparent, and metal-free FETs that utilize SWNTs as both the channel and all three electrodes (drain, source and gate). Poly(vinyl alcohol) (PVA) film was employed as the gate insulator and the substrate. Since the polymer substrate was very thin ($t \sim 10 \mu\text{m}$) compared to other commonly used transparent plastic supports—poly(ethylene terephthalate) (PET) or poly(ethylene naphthalate) (PEN)—the device was highly flexible and was characterized in various shapes (flat, bent, and wrinkled). We found only a small degradation of the electrical properties was observed although the film could be heavily crumpled. An indium tin oxide (ITO) film, which is the conventional transparent conducting materials, does not demonstrate such flexibility [3]. Possibility of the all-SWNT device as novel applications will be discussed.

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[2] S. Aikawa, R. Xiang, E. Einarsson, S. Chiashi, J. Shiomi, E. Nishikawa, and S. Maruyama: to be published in *Nano Res.* [DOI: 10.1007/s12274-011-0114-0].

[3] N. Saran, K. Parikh, D.-S. Suh, E. Muñoz, H. Kolla, and S. K. Manohar: *J. Am. Chem. Soc.* **126**, 4462–4463 (2004).