Electrospun Poly (3-hexylthiophene) Nanofiber Field-Effect Transistor

Abstract:
We report on a nanofiber Field-Effect Transistor (FET) with an organic semiconductor as the channel materials. Electrospun regioregular poly (3-hexylthiophen) (RRP3HT) nanofibers showed good field-effect modulation characteristics with holes as the major carriers. RRP3HT nanofibers, with uniform diameters of 100-500 nm and length of millimeters, were deposited onto SiO$_2$/Si substrate in a bottom-contact configuration by a scanned electrospinning process from chloroform solutions. The transistor exhibited an effective field-effect hole mobility of 0.013 cm$^2$V$^{-1}$s$^{-1}$ in the saturation regime, and a current on/off ratio of $10^3$ in the accumulation mode. These levels of gate-induced performance prepare such nanoscaled organic FET to be useful in low-cost microelectronic applications. Electrospinning offers an attractive means of fabricating one-dimensional polymer FETs with good controllability.

Summary:
We studied polymer nanofiber FETs based on electrospun RRP3HT. This work presents a new approach of fabricating solution-processed conjugated polymer as one-dimensional FET structures, without the use of advanced lithography steps. These p-type nanofiber transistors achieved properties close to those of its bulk film counterpart. Effective mobility values were as high as 0.013 cm$^2$V$^{-1}$s$^{-1}$, with ON/OFF current ratio of $10^3$. Such levels of mobility and on/off ratio have been demonstrated to be sufficient and useful as key element in novel optoelectronic integrated polymer devices and circuits, e.g. transistors to drive active-matrix displays in low-cost flexible displays.

References:
Electrospinning offers an attractive means of fabricating one-dimensional polymer FETs with good controllability.

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Nanofiber FET is appealing for low-cost high-density microelectronic applications.

Figure 1: SEM image of a typically electrospun RRP3HT nanofiber deposited over pre-patterned SiO$_2$/Si substrate. Inset: A fluorescence image showing the Au electrode pattern underneath a RRP3HT nanofiber.

Figure 2: $I_{ds}$ vs. $V_{ds}$ characteristics of a RRP3HT nanofiber FET (effective channel length 10 µm and diameter (channel width) 180 nm) showing the accumulation operation mode when different negative gate bias applied.

Figure 3: Transfer characteristics ($I_{ds}$ vs. $V_{gs}$) of the same nanofiber FET under study operated at a constant drain bias of ~50 V.