Advances in Materials for Printed Transistors

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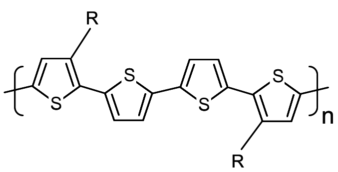
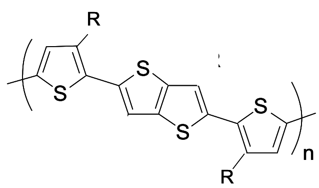
Printed thin-film transistors (TFTs) have received profound interests as an alternative to their silicon counterparts for use in fabricating next-Gen microelectronics by virtue of projected low manufacturing cost and certain salient features (e.g., thin and lightweight characteristics, structural flexibility, etc.) that printed TFTs bring to device architecture. The economic advantages stem from engaging low-cost printing techniques (e.g., screen printing, gravure, flexography, etc.) for deposition and patterning in place of traditionally costly high-vacuum, high-temperature photolithographic processes. To render printing TFTs possible, solution processable materials are necessary.

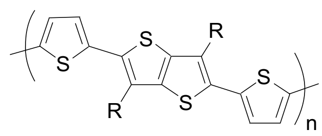
Foremost among these materials are solution processable semiconductors. We focus on polymer semiconductors for their easy solution processability and consistent and reproducible performance characteristics. PQT (I)[1] was the first polymer semiconductor which provided high field-effect transistor (FET) properties in solution-processed TFTs under ambient fabrication and characterization conditions. Variants of PQTs such as those with fused thiophene rings (e.g., II and III)[2] were subsequently reported to have higher mobility, but requiring higher fabricating temperatures as well.



(I)



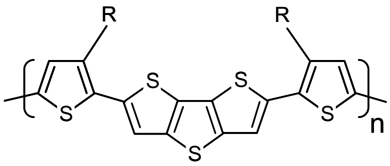
(II)



(III)

However, these polymer semiconductors require processing in environmentally undesirable solvents such as chlorobenzene to achieve high mobility. It is practically difficult if not impossible to use environmentally friendlier solvents such as hydrocarbons or THF to fabricate functional TFTs from these semiconductors due to their limited solubility.

To overcome this safety concern in manufacturing, we recently developed a novel class of polymer semiconductors (IV) which could be processed in environmentally benign solvents such as hexane to give high FET mobility.[3]



(IV)

TFTs fabricated from (IV) were relatively stable even when heated to about 200º C. No apparent changes in mobility and other FET characteristics were noted.

Similarly, we had also developed printable conductors using specifically designed gold and silver nanoparticles.[4] Printable inks could be formulated from these metal nanoparticles and printed to give highly conductive features after thermal annealing at temperatures which are compatible with commercial plastic substrates.

For printable gate dielectric, we adopted a bilayer design comprising of a top polysiloxane layer and a bottom poly(vinylphenol) layer.[5] Solution-processed TFTs on a plastic substrate with a PQT semiconductor, "gold nanoparticle" electrodes, and a bilayer gate dielectric of this nature exhibited FET characteristics which are competitive with those of TFTs fabricated with evaporated gold electrodes and SiO_2 dielectric on silicon wafer.

Acknowledgements:

The contributions of my former colleagues from Xerox Research Centre of Canada and my present colleagues from Nanyang Technological University to this work are gratefully acknowledged.

References and Notes:

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