Polymeric Thin-Film Transistors and Microfluidics for Sensing Applications

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Polymeric/organic **t**hin **f**ilm **t**ransistors (PTFTs) possess many attractive advantages including low-cost manufacturing, ease of fabrication and relatively suitable electrical performance characteristics for niche applications such as large area electronics, drive transistors for large area displays, flexible electronic systems or radio-frequency identification (RFID)tags. To date, there have been many publications exploring these applications. However, applications of PTFTs combined with mechanical or fluidic components in sensing systems have not been as extensively investigated as yet. And because of its low-cost manufacturing and compatibility with microfluific components fabricated with soft materials, PTFTs systems could offer new opportunities in sensing systems.

In this work, we present the fabrication and characterization of a microfluidic component integrated onto a polymeric thin-film transistor (μF-PTFT). The μF-PTFT uses diketopyrrolopyrrole β-unsubstituted quaterthiophene (DKPP-βT) organic semiconductor film on a thermally oxidised degenerately doped silicon wafer (gate) and gold electrodes for drain and source (see Fig below – left part). The polymer DKPP-βT is deposited by spin coating onto OTS self-assembled monolayer on the oxide. Then, gold electrodes are deposited by vacuum evaporation through a shadow mask on top of the semiconducting polymer. The OTFT channel width is W=6mm and length L=0.5mm.

To integrate the PTFT with the microfluidic component, we used a polydimethylsiloxane (PDMS) microfuodic channel prepared by a mold technique. Its length was 10mm, width was 0.2mm, and it was placed onto the OTFT (see Fig below, right side). Here, the microfluidic channel is aligned in the OTFT channel. The fluid (or air) is in direct contact with the polymeric semiconductor.

For our experiments, we used tubes and syringes to inject air or solutions of different pH and salinity into the microfluidic channel. Then we measured the current voltage characteristics of the OTFT sequentially for several times in trails by alternating different solutions and air for the measurements.

From each electrical measurement, the most important PTFT parameters - threshold voltage, mobility, mobility enhancement factor, contact resistance, subthreshold slope and leakage current, were extracted. Our extraction used at least three characterization methods to check for variation in the extracted electrical parameters.

The main observation is that deionised or salty (0.01M KCl or NaCl) water and acidic solutions with 1.5pH do not degrade the PTFT's electrical characteristics at low gate bias, as compared to the characteristics with air in the microfluidic channel. The current decreased at high gate bias in a solution of 1.5pH in the microfluidic channel and recovered consequently when deionised water was injected. However, a solution of high pH=10 immediately damaged the device, perhaps, washing-out the organic semiconducting film, since the currents of the PTFT were drastically decreased. Nevertheless, for solutions with pH≤7, the μF-OTFT has excellent stability, as in air, with mobility consistently larger than 0.2cm²/Vs, steady values for contact resistance, leakage current and subthreshold slope. The threshold voltage varied as in air.

These results imply that PTFTs with DKPP-βT polymeric semiconductor is stable in wet environment. The good news that this material does not need special encapsulation, while other organic semiconductors experience severe degradations when exposed to air and water.