Characterization of Organic Field-Effect Transistors for OLED Displays

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The field of organic semiconductor materials and devices is rapidly expanding due to the commercialization of novel organic electronic technologies, such as organic light-emitting diodes (OLEDs), and organic photovoltaic cells. Among the organic devices that have been actively studied are organic field-effect transistors (OFETs) which are compatible with low temperature substrates, such as plastic foils and thus, enable design of large-area circuits. The number of papers published each year pertaining to OFETs is increasing rapidly, and a new conference titled Organic Field-Effect Transistors was organized in 2002 under the Society of Photo-Optical Instrumentation Engineers (SPIE).

We are developing OFET arrays as sensors and switches for OLEDs. Today’s displays, using OLEDs, consume less power and have higher contrast and better hue/saturation compared to liquid crystal displays, suggesting OLEDs may be the next generation of flat panel displays. However, OLEDs degrade severely with usage. The quality of OLED display images degrades over time because not all pixels are used equally, leading to undesirable burn-in artifacts. One solution to this problem is to use optical feedback to correct for the change in OLED pixel brightness. Optical sensors are placed behind each pixels, and the signal captured by these sensors are used to control the corresponding OLED pixel. In our implementation, the sensor/switch arrays are fabricated in OFETs because of their compatibility with OLED fabrication.

In this project, we are modeling OFET response by investigating the governing physical processes to aid the design of OFET circuits, such as the ones used in OLED display panels. Parameters such as mobility, threshold voltage, and contact resistance are extracted, and peculiarities like mobility dependency on the gate bias are explored. Mobility and contact resistance has been extracted via various methods, and charge storage in the channel and the effect of charge trapping are being investigated primarily through I-V and C-V measurements (Figure 1) and specialized structures (Figure 2).

Figure 1: Capacitance vs. channel length measured directly in 1000µm-wide OFETs.

Figure 2: Array of lithographically patterned OFETs fabricated at MTL.