Combinatorial Sensing Arrays of Phthalocyanine-based Field-effect Transistors

M. Bora, D. Schut (HP), M.A. Baldo

Of the millions of molecular species floating in air or dissolved in water, a substantial fraction can be smelled and uniquely discriminated[1]. Biological systems achieve this functionality with a multitude of non-specific receptors. In this project, we are developing gas sensors based on combinatorial arrays of organic transistors. The combinatorial approach reduces the need to develop specific receptors for each and every molecule of interest. Rather, our sensors are based on exploiting the wide variation in interactions between molecules and metal ions[2], an approach previously employed in colorimetric sensors[3].

We have fabricated gas-sensitive organic transistors each consisting of an approximately 10-nm-thick polycrystalline layer of a metallophthalocyanine (MPC) with gold source and drain contacts. The width and length of the channel for each transistor is 2 mm and 50 µm, respectively. The charge-carrier mobility is typically between $10^{-3}$ and $10^{-4}$ cm²/Vs. But the transconductances of various MPC transistors (CoPC, CuPC, ZnPC, and NiPC) are observed to vary when exposed to different gases (acetonitrile, tetrahydrofuran, and toluene); channel current in MPC transistors decreases linearly with increasing solvent concentration (Figure 1). The transient response of the current modulation (Figure 2) is chemically selective and depends on the interaction between the solvent and the central metal atom in the MPC. The linear dependence of channel current on solvent concentration, the steady state current modulation, and the transient response of the MPC transistors are all consistent with the disruption of percolation pathways leading to modulation of transistor channel currents. Since the sensors can be manufactured simply by inkjet printing on a patterned substrate, they may find application as single-use diagnostic aids.

![Figure 1: The linearity of MPC sensors is tested by modulating the solvent concentration ($V_{ds}=-20V$, $V_g=-20$ V).](image1)

![Figure 2: The transient rate of channel current recovery, $k_{OFF}$, after removal of solvent vapor in units of min⁻¹, summarized for various MPC-solvent combinations. Transistor bias conditions are $V_{ds}=-20$ V, $V_g=-20$ V.](image2)

REFERENCES: