Heterojunction Photoconductors for Chemical Detection

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We have developed and demonstrated a solid-state sensor platform that directly transduces the chemosignal of a fluorescent polymer-chemical interaction into photocurrent. In addition to the direct transduction mechanism, the sensor separates the chemosensing and conduction processes across the two different films, enabling independent optimization of each film to serve a specific function [1]. Conceptually, the device consists of a Type-II bilayer heterojunction deposited on planar electrodes that enables the application of an electric field in-plane with the interface. The bilayer heterojunction is realized by spin-casting a chemosensitive fluorescent polymer on top of a sputtered metal oxide film.

Figure 1 depicts device operation: 1) absorption of illumination creates excitons, 2) excitons diffuse to the interface, 3) band offsets enable efficient exciton dissociation into free carriers, and 4) transport of photogenerated, free carriers in the photoconductive channel. The presence of an analyte will strongly modulate the photoluminescence (PL) efficiency of the chemosensitive fluorescent polymer, which signifies a change in the population of excitons that can radiatively decay [2]. Altering the exciton population changes the carrier concentration at the heterointerface, which results in a change in the measured photocurrent.

Initial testing of bilayer sensors, incorporating various polymers as the EGL and SnO_2 (doped 30% O_2) as the CTL, demonstrates an upper sensitivity limit to TNT detection of approximately 10 picograms of material in a few seconds. Figure 2 compares the spectral response of a 100-nm film of SnO_2 to a bilayer device (100 nm SnO_2/5nm HW polymer) before and after exposure to saturated TNT vapor. The inset shows the real-time change in photoconductivity at the absorption peak of the polymer when TNT vapor is introduced at time t = 0. These results prove the bilayer sensor concept and hold promise for the development of a sensitive, highly specific, portable chemical sensor platform with potential for a wide array of applications.

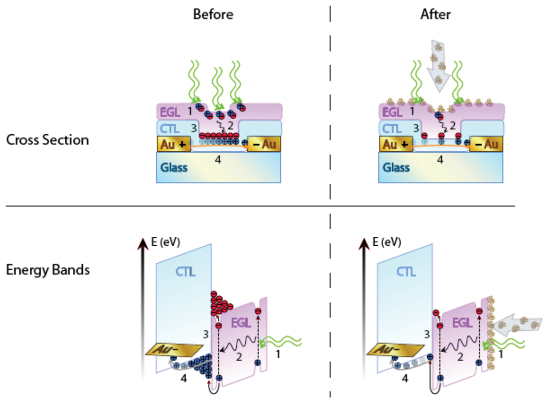

FIGURE 1: Energy band diagrams and cross-sections of bilayer sensor consisting of an exciton generation layer (EGL) and a charge transport layer (CTL) before and after exposure to a particular analyte.

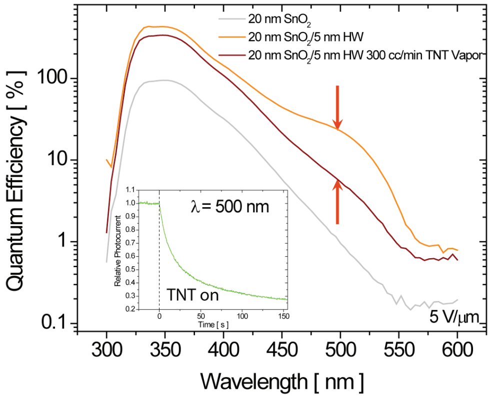

FIGURE 2: Semilogarithmic spectral response plot of HW polymer/SnO2 bilayer sensor before (orange) and after (brown) saturated TNT vapor exposure. Response of 20-nm SnO2 film (grey) is shown for comparison. Inset: Time response of TNT sensing action at ë = 500 nm. TNT vapor is introduced at time t = 0 s.

REFERENCES

[1] J. Ho, A. Arango, and V. Bulović, "Lateral Organic Bi-layer Heterojunction Photoconductors," *Applied Physics Letters*, vol. 93, 063305, August 2008.

[2] S. W. Thomas, G. D. Joly, and T. M. Swager, "Chemical Sensors Based on Amplifying Fluorescent Conjugated Polymers," *Chemical Review*, vol. 107, pp. 1339-1386, March 2007.