CHEMICAL DETECTION USING SINGLE-WALLED CARBON NANOTUBES

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We have developed electronic devices and sensors that use two-dimensional random networks of SWNTs as the active electronic material [1]. Such network devices display the aggregate properties of many randomly distributed SWNTs and can be processed into devices of arbitrary size using conventional microfabrication technology. We report here on the results of our efforts to develop chemical sensors based on SWNT networks.

Initial work at Stanford University [2] established that the electrical resistance of SWNTs is sensitive to molecular analytes that undergo a charge transfer upon adsorption. However, serious drawbacks of such conductance-based sensors are that they generate substantial 1/f noise, many important analytes do not undergo a significant charge transfer, and many that do so also exhibit a long desorption time, so that the sensors operate more like dosimetesr than real-time sensors.

We have discovered a new transduction process, surface enhanced capacitance, which eliminates the shortcomings mentioned above [3]. This surface capacitance is a measure of the electric-field-induced polarization of molecular adsorbates. This transduction mechanism is fast, sensitive, and completely reversible, and responds linearly to a much broader class of chemical vapors, ranging from highly volatile liquids to low-volatility solids such as explosives. Chemical specificity and large additional response gain is achieved by applying chemoselective coatings to the SWNTs. These coated SWNT capacitors outperform commercial sorption-based chemical sensors in both speed and sensitivity.

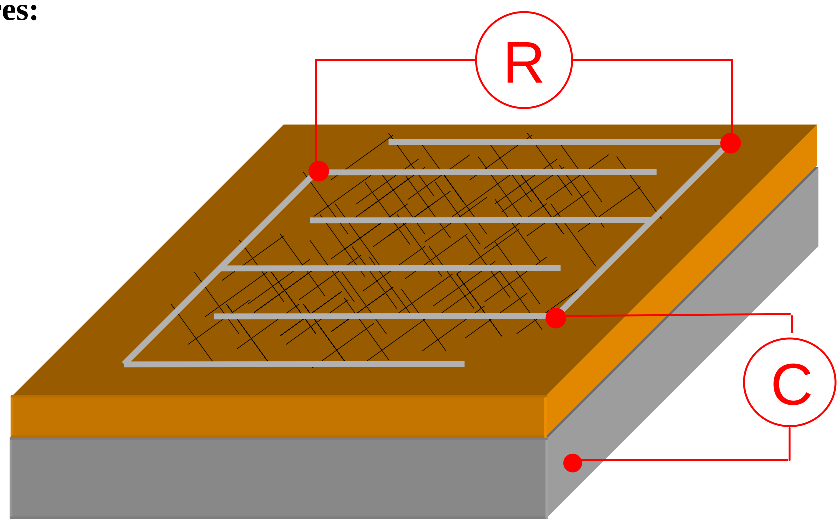
References:

[1] E.S. Snow, J.P. Novak, D. Park and P.M. Campbell, *Appl. Phys. Lett.* **82**, 2145 (2003).

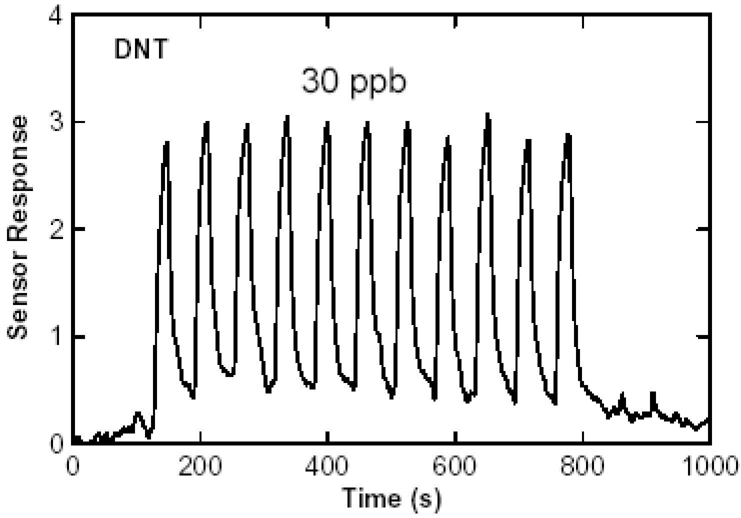
[2] J. Kong, et al., *Science* **87**, 622 (2000).

[3] E.S. Snow, et al., *Science* **307**, 1942 (2005).

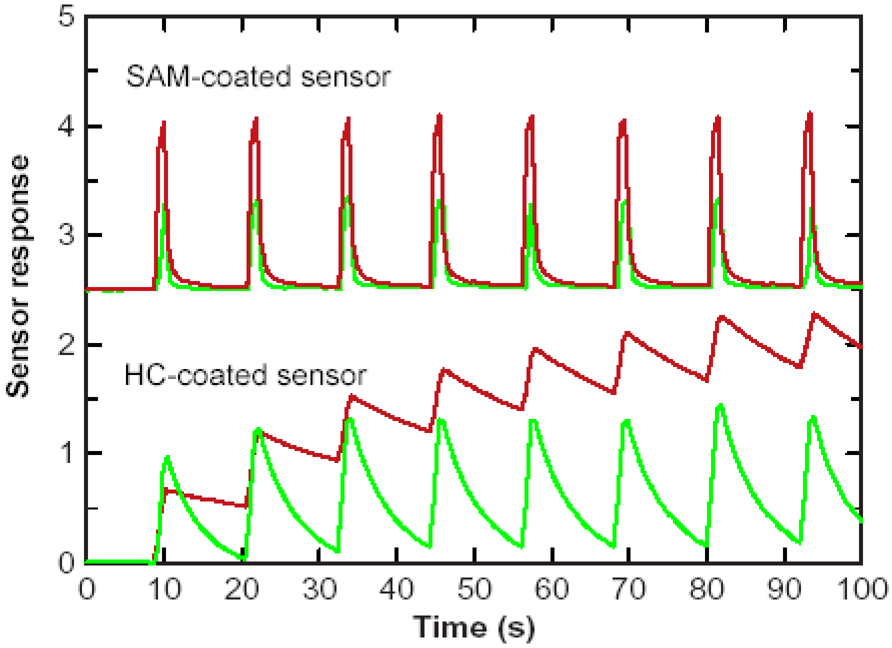
Figures:



Schematic of the SWNT chemicapacitor. The SWNTs are grown by CVD on a thermal oxide layer on a conducting Si substrate. The SWNT network and the substrate form the two plates of the capacitor. The interdigitated electrodes allow for simultaneous monitoring of both the capacitance and the network conductance.



Capacitance response to repeated 10 s, 30 ppb doses of dinitrotoluene (DNT). The surface enhanced capacitance effect can be used to detect the vapors of both high volatility liquids and low volatility solids such as explosives.



Capacitance response of two sensors to repeated 2 s doses of the nerve agent simulants $(CH_3O)_2P(O)H$ (green) and $(CH_3O)_2P(O)CH_3$ (red). The sensor in the two upper traces was coated with a monolayer of hexafluoroisopropanol. The sensor in the lower two traces was coated with ~ 100 nm-thick layer of a chemoselective polymer. The amplitude and temporal responses can both be used to discriminate chemically similar analytes.