CARBONE NANOTUBE MAT SENSORS FOR TOXIC GAS DETECTION

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Carbon nanotubes are especially well suited to chemical sensor design. Indeed, they show remarkable electrical characteristics, high conductivity for metallic, sharp on/off transition for semiconducting nanotubes. Beside their conductivity is extremely sensitive to changes in the environment of the nanotube. They can also be chemically functionalized by covalent grafting onto the nanotube walls.

Snow et al [1] have built gas sensors based on carbon nanotube networks as the reactive sensor, using filters to achieve chemical selectivity. In the current project, we implemented chemical selectivity directly onto the nanotubes by grafting reactive probes onto the nanotube walls (Scheme 1). The functionalized nanotubes were then deposited onto a chip using dielectrophoresis, forming connected micron sized carbon nanotube network transistors, the conductivity of which was measured as a function of reaction with toxic agents. Gas reaction with probes changed their electrical charge, inducing a local chemical gating effect onto nanotube conductivity.

Two kinds of probe were grafted through diazobenzene addition onto nanotubes. Diazopyridine was used as a model probe for alkylant detection. A selective cyclizing probe, designed for highly toxic organophosphonate detection [2], has been modified to add an amino moiety, later converted into a diazo group. Grafting rate was characterized by Raman spectroscopy and XPS. A low grafting rate was achieved to preserve nanotube conductivity.

Grafted and pristine carbon nanotubes were then deposited onto chips using dielectrophoresis. Diluted suspensions of nanotubes in NMP submitted to a relatively low frequency (100kHz-1MHz) electrical field between gold electrodes resulted in dense, thin networks of carbon nanotubes of 2-3kΩ resistance (figure 2).

Preliminary tests of alkylating agent reactivity onto pyridine derivatized nanotube sensors have shown a 2 fold increase in resistance compared to a 8% resistance increase for pristine nanotube networks. Further XPS analysis has shown that the gas-probe reaction was not complete, probably because of low probe availability in nanotube bundles. Work is in progress to increase the probe availability to gas and achieve gate bias enhanced sensitivity in electrical detection.

References:

[1] Novak, J. P., E. S. Snow, et al., Applied Physics Letters, **83** (2003) 4026.
Snow, E. S., F. K. Perkins, et al., Science, **307** (2005) 1942.
[2] Zhang, S. W. and T. M. Swager., Journal of the American Chemical Society, **125** (2003) 3420.

Figures:

Scheme 1: gas sensor detection principle

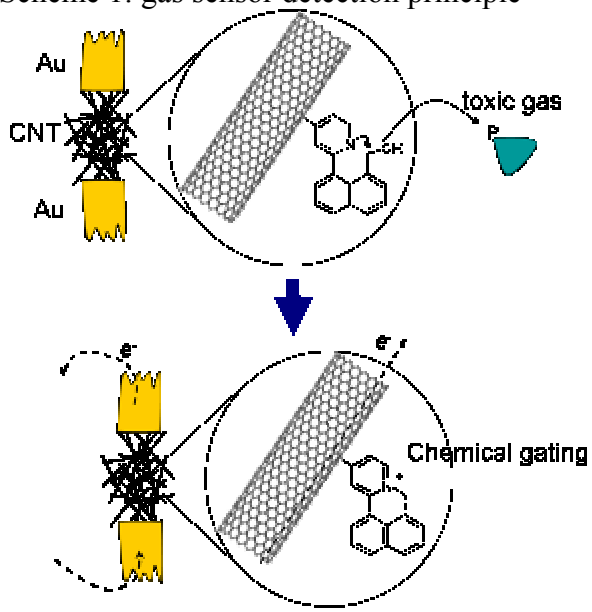

Figure 2 : SEM picture of pristine CNT mat connected onto chip.