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Advanced Sensors based on Carbon Nanotube Networks

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Single wall carbon nanotubes (SWNTs) are useful materials for a variety of electronic applications. The relative chemical passivity and environmental robustness of SWNTs suggests that they could be suitable materials for environmental sensors. Kong et al. * have demonstrated sensing of biological and chemical analytes from liquid and gaseous ambient, respectively. We have extended this work in several ways. An important criterion for sensors is the noise level, which sets a lower limit on sensitivity. It is shown that one of the weaknesses of nanoscale devices prepared from discrete SWNTs, high 1/f noise, is greatly ameliorated by the use of interconnected random networks of SWNTs to make large, or "macro" scale, devices. While changes in conductance can be used to indicate the presence of adsorbates of volatile analytes, it is shown that a capacitor configuration, utilizing the carbon nanotube network (CNN) as one electrode, leads to a much more sensitive, responsive, and accurate detector, suitable for use with a wide range of materials. In general, the capacitance of such a detector is proportional to the ambient fraction of equilibrium vapor pressure times the dipole moment of molecules constituent in ambient. Thus, saturated atmospheres of extreme low-vapor pressure polar materials (e.g., explosives) can induce responses greater than below-saturation atmospheres of highly volatile materials, or even saturated atmospheres of non-polar materials. This response can be further enhanced by the deposition of self-assembled monolayer or ultra-thin polymer coatings on the CNN or device substrate. Use of such modifications allows specificity, by comparing responses from each of a set of modified sensors to challenge. *J. Kong, N.R. Franklin, C.Ahou, M.G. Chapline, S. Peng, K. Cho, and H. Dai, Science 87, 622 (2000).