Breath-level detection of hydrogen sulphide in humid air by arrays of gold nanoparticle-functionalized carbon nanotubes

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During the past decade, the analysis of exhaled breath has been intensively considered as a non-invasive and cost-effective method for the precise identification of certain diseases [1]. For example, it has been previously demonstrated that increased concentrations of NH_3 can be correlated to kidney failure and *Helicobacter Pylori* infections [2]. Similarly, H_2S has been recently proposed as a marker for the precise identification of gastrointestinal diseases like irritable bowel syndrome (IBS) and small intestinal bacterial overgrowth (SIBO) [3]. Nevertheless, the high complexity of exhaled breath, containing over 3500 components, keeps representing a great challenge for emerging gas sensing technologies in terms of response time, sensitivity and selectivity.

In this context, we present the selective detection of low concentrations of H_2S gas in humid air and room temperature using a multichannel sensing platform based on semiconducting single-walled carbon nanotubes (sc-SWCNTs) functionalized with gold nanoparticles (AuNP). The platform consisted of 64 sensors individually addressed by a dedicated multiplexing system (Figure 1a). The electrodes we fabricated by standard UV-lithography and metal deposition techniques followed by the deposition of sc-SWCNTs using a controlled dielectrphoretic process (DEP). The nanotubes were then functionalized with gold nanoparticles (AuNP) using a potentiostatic electrodeposition technique achieving an average particle diameter of 60 nm and separation lengths of around 100 nm along the nanotube lattice (Figure 1b). AuNP-functionalized sensors demonstrated an increased and reproducible sensing performance to all tested H2S gas concentrations compared to non-functionalized sensors of 0.122 %/ppb and a calculated limit of detection of 3 ppb, similar to the odor threshold (Figure 1c and 1d). Furthermore, the sensors showed low cross-sensitivity to NH_3 and NO gases, also expected to be present in exhaled breath, as well as higher sensitivity and stability compared to commercial electrochemical-based gas sensors (AlphaSense, UK) [4]. These results suggest the potential application of our platform in the field of exhaled breath analysis.

References

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Figures

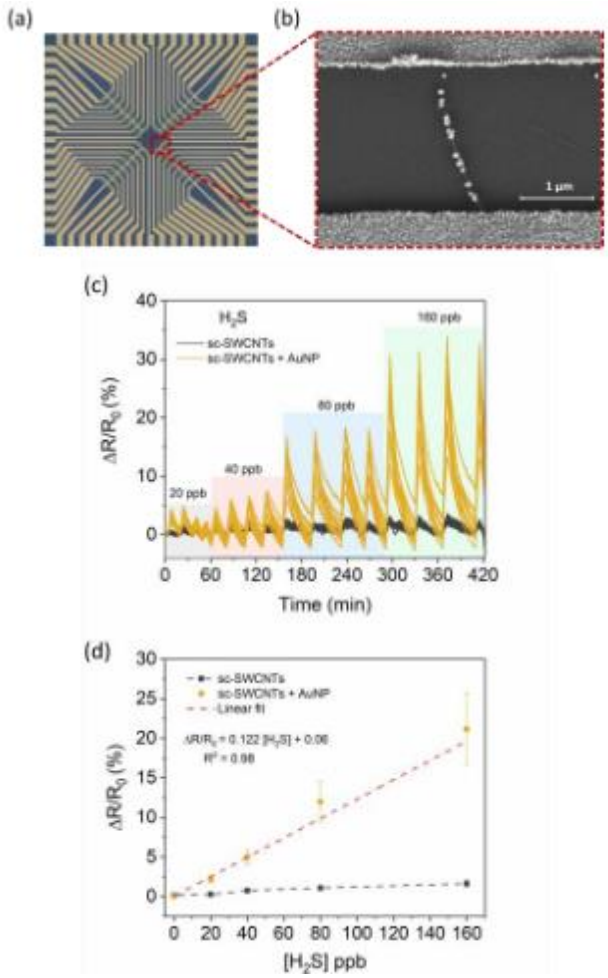

Figure 1: Multichannel gas sensing device. (a) Photographic image of microelectrodes on Si/SiO_2 wafer. (b) Scanning electron micrograph of aligned sc-SWCNT functionalized with AuNP. (c) Dynamic sensing response ($\Delta R/R_0$) of AuNP-functionalized and non-functionalized sensors to 20, 40, 80 and 160 ppb of H_2S gas in humid air (25% Rel. Humidity). (d) Average sensing response of AuNP- and non-functionalized sensors. [4]