

# HOLLOW SILICON MICROSTRUCTURES FOR BIOMEDICAL APPLICATIONS

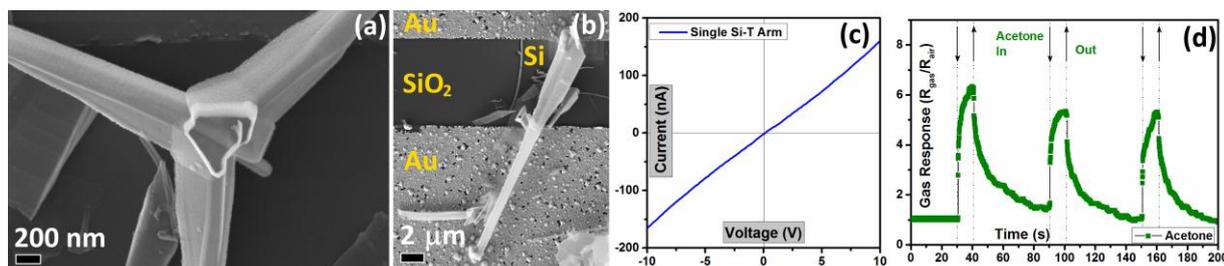
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Traditional gas sensors and biosensors based on metal oxide micro- and nanostructures, which are widely investigated in the past decades, have very high electrical resistivity (in range of  $M\Omega - T\Omega$ ). Such high resistivity is usually measured in laboratory conditions with special high-cost measurement units or equipment. Thus, such sensors are complicated to integrate into electronic biomedical devices or complementary metal-oxide-semiconductor (CMOS) systems, and needs high-cost amplifiers with very high input impedance [1-3]. In this context, silicon (Si) materials which play a central role in semiconductor industry [3], by rational controlling of morphology and physicochemical properties can be easily integrated in gas sensors and biosensors devices. Recently Adelungs' group demonstrated a novel method to synthesize hollow three-dimensional (3-D) aerosilicon microstructures [3], which demonstrated excellent potential for the development of biomedical applications, i.e. human breath analysis. Fig. 1a shows the SEM image of a hollow micro-Si-tetrapod (T). The upper arm is open and demonstrates that the Si-T is hollow. The wall thickness is in the range of 20 – 100 nm. Based on a single Si-T arm, a micro-device was fabricated (see Fig. 1b) by the procedure described earlier [4]. The diameter of the arm was  $\approx 1 \mu\text{m}$  at one end and  $\approx 2.5 \mu\text{m}$  at another end. The current – voltage characteristic demonstrates the formation of Ohmic contacts at both ends of the Si-T arm (see Fig. 1c).



**Figure 1.** SEM images of: (a) hollow Si-T and (b) of fabricated micro-device based on an individual Si-T arm. (c) Current – voltage characteristic of the micro-device on Si-T. (d) Gas response of micro-device to 50 ppm of acetone vapour. First pulse is applied at 30% RH, the other 2 peaks are applied at 70% RH.

It was demonstrated by clinical investigations/researches that diabetes patients have higher concentration of acetone vapour in their breath, compared to healthy peoples [3]. Thus, acetone vapour can be used as excellent marker for the diagnosis of diabetes mellitus in human breath, which contains a high value of relative humidity (RH). The fabricated micro-device was exposed to 50 ppm of acetone vapour at room temperature in 30% RH (see Fig. 1d first pulse) and 70% RH (see Fig. 1d least 2 pulses). It was found that the micro-device posses good gas response for 30% ( $R_{\text{gas}}/R_{\text{air}} \approx 6.3$ ). By increase RH value to 70% the gas response decrease with only 15%. It demonstrates the potential of Si-T micro-structures to develop portable and miniature breath-monitoring devices with low dependence on RH value and low power consumption.

**Acknowledgements.** This work was partially supported by the STCU within the Grant 5989.

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