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 MΩ – TΩ). 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) aero-silicon 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 ≈ 1 µm at one end and ≈ 2.5 µm at another end. The current – voltage characteristic demonstrates the formation of Ohmic contacts at both ends of the Si-T arm (see Fig. 1c).

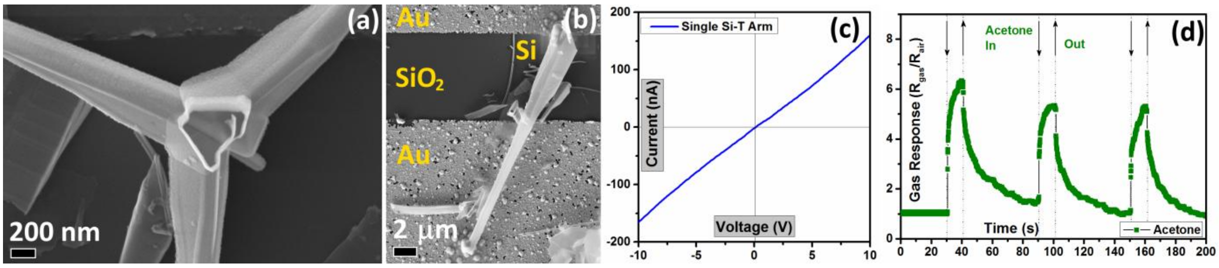

Figure 1. SEM images of: (a) hollow Si-T and (b) of fabricated micro-device based on an individual Si-T arm. (c) Current – voltage characteristic of the micro-device on Si-T. (d) Gas response of micro-device to 50 ppm of acetone vapour. First pulse is applied at 30% RH, the other 2 peaks are applied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

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[1] V. Cretu, V. Postica, A.K. Mishra, M. Hoppe, I. Tiginyanu, Y.K. Mishra, L. Chow, N.H. de Leeuw, R. Adelung, O. Lupan, J. Mater. Chem. A. **volume 4** (2016) 6527-6539.

[2] V. Postica, I. Hölken, V. Schneider, V. Kaidas, O. Polonskyi, V. Cretu, I. Tiginyanu, F. Faupel, R. Adelung, O. Lupan, Mater. Sci. Semicond. Proc. **volume 49**, (2016) 20-33.

[3] I. Hölken, G. Neubüser, V. Postica, L. Bumke, O. Lupan, M. Baum, Y.K. Mishra, L. Kienle, R. Adelung, ACS Appl. Mater. Interfaces. **volume 8**, (2016) 20491-20498.

[4] O. Lupan, V. Postica, V. Cretu, N. Wolff, V. Duppel, L. Kienle, R. Adelung, Phys. Status. Solidi RRL. **volume 10**, (2016) 260-266.