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FIB fabrication of ZnO nanotetrapod and cross-sensor

Lee Chow[*,1,2], **Oleg Lupan**[**,1,3], **and Guangyu Chai**[4]

[1] Department of Physics, University of Central Florida, Orlando, FL 32816, USA
[2] Department of Mechanical, Materials, and Aerospace Engineering, Advanced Materials Processing and Analysis Center, University of Central Florida, Orlando, FL 32816, USA
[3] Department of Microelectronics and Semiconductor Devices, Technical University of Moldova, Stefan cel Mare Blvd. 168, MD-2004 Chisinau, Republic of Moldova
[4] Apollo Technologies, Inc. 205 Waymont Court, S111, Lake Mary, FL 32746, USA

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* Corresponding author: e-mail chow@mail.ucf.edu, Phone: +1 407 823 2333, Fax: +1 407 823 5112
** e-mail lupan@physics.ucf.edu

This article presents the fabrication of zinc oxide (ZnO) nanotetrapod and cross-nanorods-based sensors. This low-dimensional device is made in a focused ion beam set-up by using nanodeposition for metal electrodes. The gas response of the sensor based on an individual zinc oxide nanotetrapod and on crossed ZnO nanorod for detection of ultraviolet (UV) light and hydrogen at room temperature is presented. It is shown that ZnO tetrapod has potential application as UV and as chemical sensor with multi-terminal construction. The chemisorbed gas molecules on the ZnO surface can extract or donate electrons to ZnO and this effect was used to monitor the electrical resistance values change of the tetrapod sensor. ZnO tetrapod sensor demonstrates sensitivity and selectivity in resistance upon exposure to UV light, H_2, O_2, NH_3, CO, CO_2, and LPG gas. The resistivity change is different for UV and for H_2 gas sensing. The presented ZnO sensor proves to be promising for application in various processes.

Introduction Recently, wide-bandgap metal oxides architectures have attracted tremendous research interest due to their ultraviolet (UV) photoresponse and their optical transparency in the visible spectral range [1–6]. In particular, zinc oxide (ZnO) is in the focus of the practical applications as sensor material due to its sensitivity to different gases and ability to operate in harsh environments and in radiation facilities [7]. The low dimensions of such nanostructures promise increase in electronic device packing density, low power consumption, and also enhanced sensing properties. Recently, it has been demonstrated that ZnO readily self-assembles into a diversity of nanocrystalline structures like nanorod-based spheres and radial spherical structures, branched nanorods, nanorod crosses, terapods [2–6, 8], etc. ZnO nanostructures with multi-terminals came in the focus of researchers because it exhibits a large surface-to-volume ratio which makes them highly susceptible to altered electrical properties during gas and biologic molecules exposure too.

Thus, unique structure of ZnO branched rods [3] and ZnO tetrapods [6, 9] with a natural junction attracted interest as possible building blocks of novel devices. At the same time, sensors based on ZnO crosses and tetrapods are multi-terminal devices. In this way, ZnO tetrapod sensors can provide several different signals at the same time. The first report of electrical contacting of single tetrapod was by Alivisatos and coworkers [10] in 2005. Newton et al. [9] has reported the ZnO tetrapod Schottky photodiodes [10] in 2006. Also, Zhang et al. [11] showed individual ZnO tetrapod as a multi-terminal sensor which can yield simultaneous multiple responses to a single input signal. Chai et al. [5], on the other hand, fabricated cross-ZnO nanorod UV sensor. The main advantages of such nanostructures are: (a) multi-terminal nature and (b) the junctions between terminals, and (c) new functionality can be envisioned. As an example in a recent work, Huh et al. [12] suggests that the junction plays a decisive role in the electrical characteristics of the ZnO tetrapod devices.