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Au-NPs/ZnO single nanowire nanosensors for health care applications

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***Abstract*— Herein, the room temperature gas sensing properties of a device fabricatedbased on an individual gold nanoparticles (AuNPs)-functionalized zinc oxide nanowire (ZnO NW) is reported. The Au-NPs/ZnO nanowires were depositedusing theelectrochemical approachin a classical three-electrode electrochemical cell. The dual beam focused ion beam/scanning electron microscopy (FIB/SEM) was usedto integrate the singlenanostructuresinto gas sensing nanodevices.The results are promising for futureapplications in monitoring H2gas for health care applications and clinical breath analysis.**

Keywords—nanosensors; hydrogen gas sensor; ZnO nanowire; gold nanoparticles

I. INTRODUCTION (*HEADING 1*)

Hydrogen is the lightest and most abundant chemical element in the universe. H_2 gas is odorless, colorless, highly reactive and highly flammable with a wide flammable range (5–75%) [1, 2]. Currently, the two largest uses of hydrogen are fossil fuel processing, ammonia production for fertilizer and as clean energy source, being by 3-times more energy dense by mass than gasoline (143 MJ/kg vs 46.9 MJ/kg) [3]. Since the 2007 discovery that molecular hydrogen has selective antioxidant properties, multiple studies have shown that H_2 has beneficial effects in diverse animal models and human disease, and can be also used as a preventive and therapeutic medical gas for various diseases [4]. H_2 have several advantages over current pharmacological therapies: (i) high diffusivity which allows to reach subcellular compartments; (ii) selective reduction of detrimental hydroxyl radicals and peroxynitrite, without decrease of the steady-state levels of nitric oxide; (iii) hydrogen treatment did not eliminate O_2^- or H_2O_2 when tested in vitro [3, 5]. In gaseous phase the H_2 can be easily inhaled using a ventilator circuit, face-mask or nasal cannula [3].

Since 2007 the number of publications on the biologically or medically beneficial effects of H_2 is still growing and are mainly focused on tissue dysfunctions, reproductive, urinary, respiratory, digestive, cardiovascular and central nervous systems, metabolic syndrome, etc. [4]. Along with the therapeutic applications, the measurement of breath hydrogen has also attracted a great attention in recent years [6]. Hydrogen in the human body is eliminated through three pathways: flatus, respiratory excretion after absorption into the systemic circulation and metabolism by colonic microbiota (through three metabolic methods) [3].

Despite the fact that the potential of clinical breath analysis has been recognized for centuries, it still remains in its infancy [7]. Breath analysis can be used to detect disease, monitor disease progression, or monitor therapy [7]. The main advantages of breath analysis are: (i) method is noninvasive; (ii) sampling procedure is safe and fast; (iii) does not require any additional apparatus and the subjects are only requested to deeply breathe into the collecting system [8].

In the case of preventive and therapeutic medical applications the safety is a primary concern with respect to H_2 transportation, storage, and administration [4]. Therefore, due to the dangerous character of H_2 gas and because it cannot be detected by human beings it is important to elaborate the devices for rapid and accurate H_2 gas detection even to small concentrations (in range of ppm) [2].

In this context, metal oxide structures are ideal candidates for gas sensing applications due to their advantages such as: (i) low cost; (ii) detection of a wide range of reducing and oxidizing gases and VOCs vapors; (iii) high sensitivity; (iv) possibility to fabricate portable devices [9-11]. For example, recently the highly selective room temperature hydrogen gas sensor was elaborated based on ZnO columnar films doped with Pd and decorated with PdO_2/PdO nanoparticles [12]. Among all types of structures, the quasi-one-dimensional (1-D) structures, such as nanowires, nanobelts, nanorods, etc., have attracted a great attention due their high surface-to-volume ratio, which makes them highly sensitive to surface reactions