Integration of Gallium Oxide Nanowires in Electronic Devices for Gas Sensing and UV Photodetection

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Solid state devices based on metal oxides are amongst the most popular types of gas sensors for monitoring toxic species, such as carbon monoxide (CO) and nitrogen oxides (NOx) [1]. In the last years, significant research efforts have been devoted to extend their fabrication to the nanoscale, due to the excellent sensing properties of nanowires, related to the high surface-to-volume ratio. In general, the exclusive properties of nanostructured materials in respect to bulk materials have attracted research efforts because of their potential applications in electronic devices [2]. Although great advances have been achieved in synthesis, characterization of the fundamental properties and sensing mechanism of the materials, the fabrication of reliable and reproducible sensors based on these structures is still scarce due to the difficulties of the manipulation and characterization of the sensors [3].

Gas and optical sensors based on individual nanowires have been demonstrated and integration of nanowires in prototypes devices has proven its feasibility [4]. Nevertheless, the fabrication of electrical contacts with high stability, low contact resistances and ohmic behavior remains a challenge. Focused Ion Beam (FIB) lithography is a powerful fabrication technique for prototypes with dimensions in the range of the nanoscale [5]. Using this technique, electrical contacts are fabricated over the nanowire with electron beam assisted deposition while ion beam assisted deposition can be used to extent these contacts to large metal electrodes, giving macroscopic access to the electrical response of the nanowire while preserving the nanowire from ion damage (see Figure 1). The resulting devices provide an excellent opportunity to study the electrical, optical and gas sensing properties of individual metal oxide nanowires [6].

Gallium Oxide Nanowires are synthesized by the controlled thermal annealing of metallic gallium under argon flow, at temperatures between 1100ºC and 1300 ºC. Gallium oxide compacted powders were used as substrates. The growth mechanism of the nanowires is based in a vapor-solid process avoiding the use of a foreign catalyst [7]. The nanowires obtained exhibit a high crystal quality, which has been demonstrated by Transmission Electron Microscopy (TEM) techniques.

These Gallium Oxide Nanowires are contacted electrically by using FIB techniques and their electrical characteristics are studied in detail. The electrical response of these devices can be measured in different gas atmospheres studying the effect of surrounding gas in the electrical conduction of the nanomaterials. Finally the photoconductivity properties inherent to metal oxides can be exploited in the form of nanowires by the use of these devices also as photodetectors.

The potential of these metal oxide nanowires for their integration in sensing devices and the possibility of developing highly efficient future sensors will be discussed.

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Figures

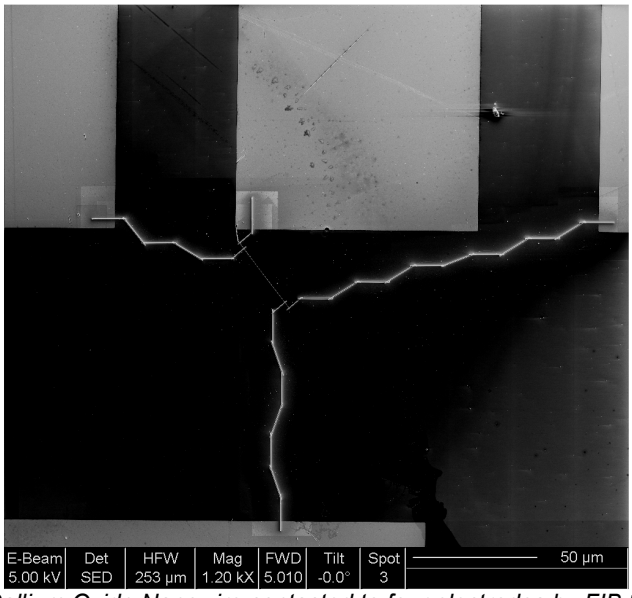

Figure 1. Gallium Oxide Nanowire contacted to four electrodes by FIB techniques.