Individual Nanowires Contacted onto Microhotplates: A Strategy for Improving the Performance of Gas Nanosensors

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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 oxide (NOx) [1]. In the last years, significant research efforts have been devoted to extend their fabrication to the nanoscale, using nanowires and nanotubes as building-blocks, because of their excellent sensing properties related to the high surface-to-volume ratio. The final aim of this new field of research is to improve the performance of current sensors by taking advantage of the unique and intrinsic properties of nanomaterials.

Up to now, the feasibility of using nanowires as basic elements of electronic devices, such as gas and optical sensors have been demonstrated, being possible the modeling of their electrical properties [2]. Nevertheless, the fabrication of these nanodevices has been hindered because of the manifold problems which arise to electrically access these nanostructures in a controlled and reproducible way. That is to say, the fabrication of electrical nanocontacts with high stability, low contact resistances and ohmic behaviour remains a challenge. To overcome this limitation, some fabrication strategies have been reported [3], demonstrating that reliable, reproducible and low-cost prototypes based on individual nanowires can be attained [2]. Nevertheless, most of these new technologies are still in their infancy.

In particular, the efficiency of Focused Ion Beam (FIB) lithography has been demonstrated elsewhere [4]. Using the abovementioned technique, the electrical access to individual nanomaterials is achieved fabricating metal nanocontacts according to a process which combines both electron and ion assisted platinum deposition. The resulting devices provide an excellent oportunity to study the electrical, optical and gas sensing properties of individual metal oxide nanowires [5].

Metal oxides' gas sensing characteristics are usually temperature-dependant; being the optimal working conditions unique for each material and gas molecule to be detected. Thus, the integration of nanowires in sensing devices requires the possibility of modulating their temperature with an easy-to-control and low power consumption system. Therefore, the combination of nanowires and suspended microhotplates is a promising solution. Microhotplates include microheaters that allow setting the working temperature up to 600 K. Their reduced dimensions guarantee thermal dynamics response much faster than the bulky counterparts, as well as having extremely low power consumption requirements. In this experimental approach, individual nanowires are placed onto a microhotplate, and contacted with FIB assisted techniques. In these sensing platforms, the size-reduction of the microhotplates, which are suspended by a few arms contribute to an important reduction in the power consumption. For this reason, present development efforts are focused on the fabrication of even smaller hotplates with ultra-lower power consumption.

In this contribution, our work to achieve this ambitious goal will be presented. Furthermore, these first prototypes can be combined with energy-scavenging technologies to have ultrafast circuits based on nanomaterials. In particular, we will discuss the possibility to develop self-powered gas sensing nanosystem. Despite the research and development of these devices are still ongoing, these technologies may overcome cost and size limitations of lab-class equipments, which are usually needed to work with nanomaterials.

References:

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Figures:

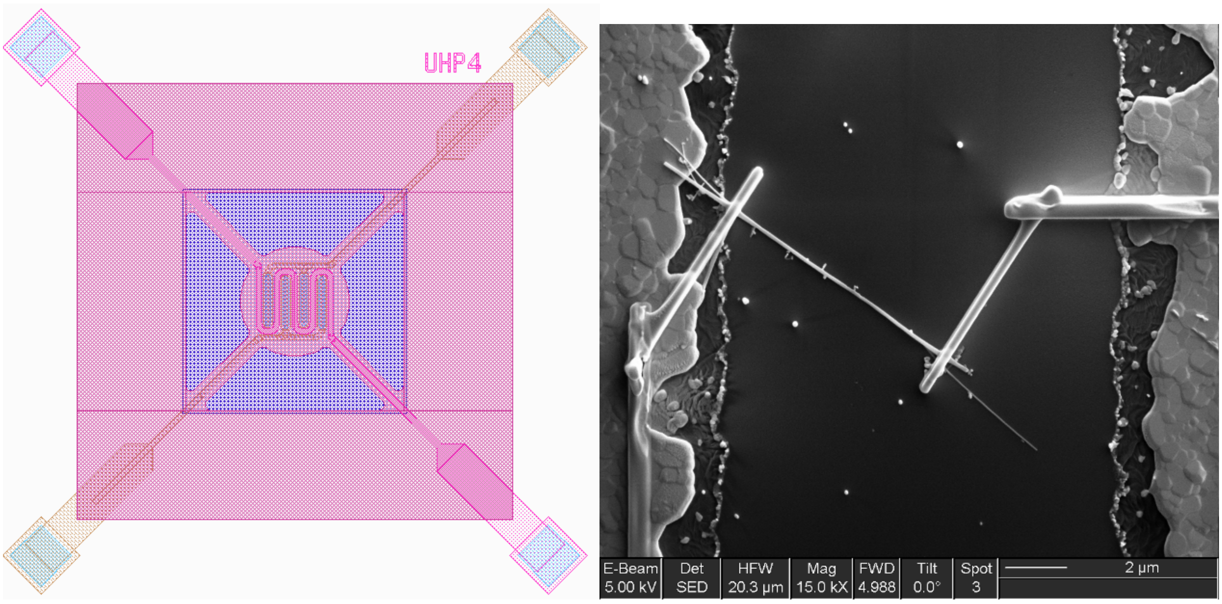

Figure 1. Left: Schematic of the design of a microhotplate with integrated heaters. Right: SEM micrograph of a single nanowire contacted on a microhotplate.