High Performance in Self-heated Single Nanowire Based Sensors

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Research on 1-D nanomaterials is a subject of great interest due to the possibility of using them as building blocks of new devices. Basic characterization has been performed on these materials and primary integration in sensors is currently researched. In this work, we focused our attention in the modulation of the temperature of these brand new devices due to the application of controlled probing currents.

Individual nanowires are accessed by means of the fabrication of platinum nanocontacts with a Focused Ion Beam (FIB) system, following a process which combines both electron and ion assisted depositions [1]. These contacts fabricated over the nanowire and extended to pre-patterned microelectrodes allow the characterization of the sensing capabilities of the nanowire to different gas species [2] at different temperatures with the help of a furnace.

Additionally an innovative method of setting the working temperature of the device has been used recently. In these new systems, the nanowires are contacted over suspended MEMS hotplates that contain integrated heaters [3][4]. The thermal isolation and reduced dimensions of these microhotplates allow faster modulation of the working temperature with reduced power consumptions.

As chemiresistors, nanowires are elements prone to experience the Joule effect due to their small dimensions, heating themselves above working temperature. Contact degradation and device failure have been reported as a result of the high temperatures produced when uncontrolled probing currents are applied [5].

Nevertheless, the use of controlled probing currents to achieve optimal working temperatures with extremely low power consumption is an issue of great interest for the potential applications in portable and autonomous single nanowire based gas sensors.

We prove that it is possible to use this method to equal the performance of nanowires heated over microhoplates when characterizing their sensing capabilities towards NO_2, and that device preservation it is possible by controlling the probing current [6].

In summary, we demonstrate that self-heating effect can be applied to the characterization of single nanowire based gas sensors with low power consumption, presenting an importance advance in power efficiency and miniaturization.

References:

[1] A. Vilà, F. Hernández-Ramirez, J. Rodríguez, O. Casals, A. Romano-Rodríguez, J.R. Morante and M. Abid, Materials Science and Engineering C, **26** (2006) 1063 – 1066.
[2] F. Hernández-Ramírez, J. Rodríguez, O. Casals, E. Russinyol, A. Vilà, A. Romano-Rodríguez, J.R. Morante and M. Abid, Sensors and Actuators B, **118** (2006) 198–203.
[3] F. Hernandez-Ramirez, J. D. Prades, A. Tarancon, S. Barth, O. Casals, R. Jimenez-Diaz, E. Pellicer, J. Rodriguez, M. A. Juli, A. Romano-Rodriguez, J. R. Morante, S. Mathur, A. Helwig, J. Spannhake, and G. Mueller, Nanotechnology, **18** (2007) 495501-495505.
[4] D. C. Meier, S. Semancik, B. Button, E. Strelcov, A. Kolmakov, Appl. Phys. Lett., **91** (2007) 063118-063120.
[5] F. Hernandez-Ramirez, A. Tarancon, O. Casals, E. Pellicer, J. Rodriguez, A. Romano-Rodriguez, J. R. Morante, S. Barth, S. Mathur, Phys. Rev. B, **76** (2007) 085429-085433.
[6] J. D. Prades, R. Jimenez-Diaz, F. Hernandez-Ramirez, S. Barth, A. Cirera, A. Romano-Rodriguez, S. Mathur, J. R. Morante, Applied Physics Letters **93** (2008) 123110.