NANODEVICES BASED ON INDIVIDUAL NANOWIRES: FABRICATION STRATEGY, DEVICE PROPERTIES, DEVICE INTEGRATION AND GUIDELINES FOR FUTURE WORK

Román Jimenez-Diaz[1], Olga Casals[1], Albert Cirera[1], Juan Daniel Prades[2,3], Sven Barth[4], Sanjay Mathur[5], Juan Ramon Morante[3], Francisco Hernandez-Ramirez[2,3], Albert Romano-Rodriguez[1]

[1]MIND-IN2UB, Department Electronica, Universitat de Barcelona, E-08028 Barcelona, Spain.

[2]Electronic Nanosystems S.L., Barcelona, E-08028, Spain

[3]IREC, Catalonia Institute for Energy Research, E-08019 Barcelona, Spain.

[4]Department of Chemistry, University College Cork, Cork, Ireland.

[5]Department of Inorganic Chemistry, University of Cologne, D-50939 Cologne, Germany.

aromano@el.ub.es

In the last 15 years, nanomaterials (nanowires, nanotubes, nanobelts, ...) have emerged as potential active elements in new devices and circuit architectures thanks to their unique characteristics, consequence of their large surface-to-volume ratio, the possibility to accurately control their composition, dimensions and chemical and physical properties [1]. A large number of papers have been published dealing with the optimisation of the synthesis and fabrication procedures of these nanomaterials, several works have reported on their electrical characterisation, some of them being able to characterise individual nanomaterials. However, the number of reports on the nanodevice fabrication based on these individual nanomaterials is quite reduced, as their manipulation or the contact fabrication to them remains a process which is difficult to control.

The work which will be presented here will be the review of the research activity which we have carried out on the fabrication of nanodevices based on individual nanowires and, more concretely, monocrystalline metal-oxide nanowires. For this purpose, dual-beam focused-ion beam technology has been extensively used for the deposition of a Pt-containing material, which in this work has been employed for contact fabrication to the nanomaterials. A specific contact methodology based on the use of both electron- and ion-assisted Pt deposition on prepatterned isolated semiconducting substrates has been developed, which prevents structural damage to the nanomaterials while assuring a reasonable conductivity of the metal nanostripe and a controlled nanowire-nanostripe interface [2]. The electrical characterisation of such ensemble at different temperatures has allowe its modelling according to different mechanisms and the critical parameters for device operation have been identified [3,4].

After their characterisation, these metal-oxide-based nanostructures have been tested as nanodevice prototypes. Two different applications have been addressed: gas sensing and photodetection. The gas response of such nanodevices has demonstrated that the sensitivity to the gas atmosphere is comparable to that of their thin- or thick-film counterparts, while the response time and recovery after exposure to gas are much better, both parameters being a direct consequence of the large surface-to-volume ratio [5]. Furthermore, the use of suspended microhotplates instead of bulk substrates allows the fabrication of very low power consumption nanodevices, which are suited for their integration into portable gas alarms.

Due to the large-bandgap and photoresponse of the metal-oxide nanowires, UV photodetectors have been fabricated and tested using the same methodology as for the gas sensors. Their optical characteristics will be reviewed and critically compared to equivalent microdevices based on bulk or thin-film metal-oxide materials [6].

The design of such a system will also be addressed.

This contribution attempts to critically discuss the fabrication strategy, its impact on the electrical behaviour of the fabricated nanostructures, the fabrication of operative nanodevices, the limitations of the methodology, the design of integrated electronic systems involving such nanodevices, as well as give guidelines for future work.

Financial support from the Spanish Ministry of Science and Innovation and from the EU is acknowledged.

References:

[1] Y. Cui, Q. Q. Wei, H. K. Park, C. M. Lieber, Science **293** (2001) 1289.
[2] S. Valizadeh, M. Abid, F. Hernandez-Ramirez, A. Romano-Rodriguez, K. Hjort, J. A. Schweitz, Nanotechnology, **17** (2006) 1134.
[3] F. Hernandez-Ramirez, A. Tarancon, O. Casals, J. Rodriguez, A. Romano-Rodriguez, J. R. Morante, S. Barth, S. Mathur, T. Y. Choi, D. Poulikakos, V. Callegari, P. M. Nellen, Nanotechnology, **17** (2006) 5577.
[4] F. Hernandez-Ramirez , A. Tarancon, O. Casals, E. Pellicer, J. Rodriguez, A. Romano-Rodriguez, J. R. Morante, S. Barth, S. Mathur, Physical Review. B **76** (2008) 085429.
[5] F. Hernandez-Ramirez , J. D. Prades, A. Tarancon, S. Barth, O. Casals, R. Jimenez-Diaz, E. Pellicer, J. Rodriguez, J. R. Morante, M. A. Juli, S. Mathur, A. Romano-Rodriguez, Advanced Functional Materials **18** (2008) 2990.
[6] J. D. Prades, R. Jimenez-Diaz, F. Hernandez-Ramirez , L. Fernandez-Romero, T. Andreu, A. Cirera, A. Romano-Rodriguez, A. Cornet, J. R. Morante, S. Barth, S. Mathur, Journal of Physical Chemistry C **112** (2008) 14639.

Figures:

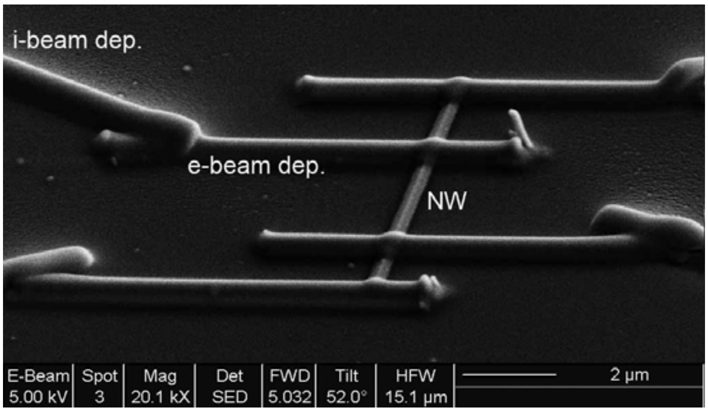

Figure 1. SEM image (tilted by 52 degrees) of a SnO2 single-crystalline nanowire contacted using electron- and ion-assisted deposition in 4-probe configuration.