TuP60

Monday

Tuesday

Wednesday

Thursday

Friday

Interesting spatial inhomogeneities in n- and p-doped InAs nanowires grown by gold-seeded molecular beam epitaxy

C. Rolland[1], P. Caroff[1,2], X. Wallart[1] and R. Leturcq[1]

[1] *Institute of Electronics, Microelectronics and Nanotechnology, CNRS - UMR 8520, Departement ISEN, Avenue Poincaré, F-59652 Villeneuve d'Ascq, France*

[2] *Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra, ACT 0200, Australia*

A cornerstone for the realization of devices using semiconductor nanowires (NWs) is to control the impurity doping. We investigate the carrier concentration along intentionally doped InAs NWs using transport measurements in NW field effect transistors (NWFETs). We studied both n- (Si) and p- (Be) doped InAs NWs grown by molecular beam epitaxy (MBE) using gold as seed particles.

In Si-doped NWs, we observe non-uniform carrier concentration along the NW, with an electron density that decreases linearly from the base of the NW towards its tip, in contrast to what has been reported for Si-doped InAs NWs grown by metalorganic vapor phase epitaxy (MOVPE) [1]. Similar inhomogeneous doping incorporation was reported for different semiconductor materials [2, 3, 4]. Additionally it was observed that the sidewall morphology of gold-free InAs NWs is drastically affected by Si-doping [5]. Interestingly we do not observe any significant tapering or sidewall nanofaceting on our nanowires, and diffusion of dopants seems to be the most relevant mechanism, as already reported in P-doped Si NWs [6, 7]. We have also grown NWs starting with an undoped section and finishing with a doped section, which allows achieving non-tapered nanowires with an homogeneous controlled carrier concentration.

p-doping of InAs NWs is usually a challenge due to the surface pinning of the Fermi level in the conduction band [8, 9, 10, 11]. We demonstrate that Be-doping of InAs NWs using MBE also leads to an inhomogeneous carrier concentration, as observed for Si-doping. However, due to the surface pinning effect, the p-doped InAs NWs show much more complex characteristics. By acting on the Be concentration we investigate different regimes where $p-n$ junctions are formed between the p-doped NW and the n-doped surface. These junctions can be sharp enough in order to produce the characteristics of tunnel diodes. We thus show a simple way to create functional junctions whithout the need of an additonal controlled n-doped segment along these NWs.

[1] G. Zhang *et al.*, J. Phys. Chem. C **115**, 2923 (2011).
[2] E. Tutuc *et al.*, Appl. Phys. Lett. **89**, 263101 (2006).
[3] G. Imamura *et al.*, Nano Lett. **8**, 2620 (2008).
[4] J. Dufouleur *et al.*, Nano Lett. **10**, 1734 (2010).
[5] H. Ghoneim *et al.*, Nanotechnology **23** 505708 (2012).
[6] J. E. Allen, D. E. Perea, E. R. Hemesath and L. J. Lauhon, Adv. Mat. **21**, 3067 (2009).
[7] E. Koren, N. Berkovitch and Y. Rosenwaks, Nano Lett. **10**, 1163 (2010).
[8] Q. Hang, F. Wang, W. E. Buhro and D. B. Janes, Appl. Phys. Lett. **90**, 062108 (2007).
[9] H.-Y. Li *et al.*, Nano Lett. **7**, 1144 (2007).
[10] A. C. Ford *et al.*, Nano Lett. **10**, 509 (2010).
[11] B. S. Sørensen *et al.*, Appl. Phys. Lett. **92**, 012119 (2008).