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III-V Semiconductor Nanowires VLS Growth: Does Arsenic Diffuse Through the Catalytic Nanoparticle?

L. H. G. Tizei[(1,2)*], T. Chiaramonte[(1)], D. Ugarte[(1,2)], M. A. Cotta[(1)]

(1) IFGW, Universidade Estadual de Campinas, CP: 6165, 13083-970, Campinas, SP, Brazil: ltizei@ifi.unicamp.br
(2) LNLS, Laboratório Nacional de Luz Síncrotron, CP 6192, 13083-970, Campinas, SP, Brazil
* Corresponding author.

Abstract – For III-V semiconductor nanowires growth by VLS, group V incorporation route is still open to debate. To study this problem we have grown by CBE two nanowires samples with the heterostructure InP/InAs/InP at two different temperatures (420 ℃ and 450 ℃), with Au nanoparticles as catalysts. ED S measurements show that close to the InP/Au catalyst there is an increase in As concent for the 450 ℃ sample. We believe that this observation is evidence that As diffuses through the Au nanoparticle and that at 450 C there is stable concentration of As that is stocked in the nanoparticle.

For III-V semiconductor nanowires VLS (Vapor-Liquid-Solid) growth it is known that group III atoms diffuse through the metallic nanoparticles and are incorporated at the metal/semiconductor interface. There is no data that confirms group V incorporation route on growth conditions.

To study this problem, we have grown by CBE two nanowires samples with the heterostructure InP/InAs/InP at two different temperatures (420 ℃ and 450 ℃), using gold nanoparticles as catalyst. Nanowires show wurtzite hexagonal crystal structure as revealed by TEM (Transmission Electron Microscpy). For the 450 ℃ sample a distinct feature is observed close to the InP/Au interface (Figure 1a), which HRTEM (High Resolution TEM) images show to be a change in structure from wurzite to zinc-blend (Figure 1b,c). To understand this feature, we studied in detail the chemical composition at the InP/Au interface region by EDS (Energy Dispersed X-Ray Spectroscopy).

For the 450 ℃ sample, the region close to the gold particle displays a narrow As rich layer which is spatially correlated to the change in structure (Figure 2). This is surprising because As is not originated from the growth atmosphere (as samples were cooled in vaccum) nor surface diffusion. We speculate that the As diffuses through the Au nanoparticle and that at 450 C there is stable concentration of As that is stocked in the nanoparticle, even during InP growth. Thus, as the nanowire is cooled As is expelled, growing a thin As rich region. This result shows that As (group V) diffuses through the gold nanoparticle [1].

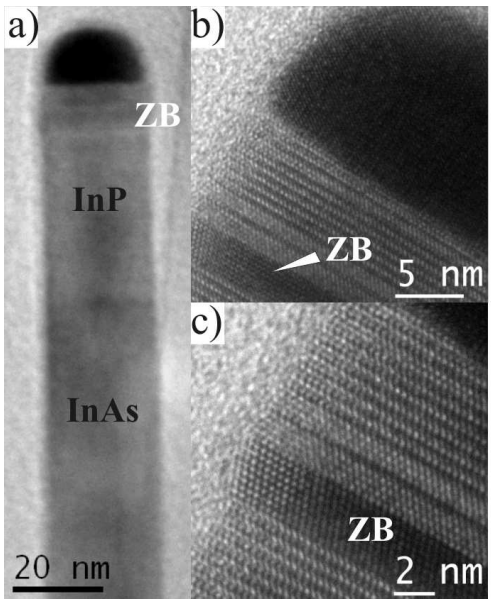

Figure 1: a) TEM image of the InAs/InP/AuNp segment of a nanowire grown at 450 ℃. Note the distinct band ma rked ZB **b,c)** HRTEM images showing that this feature is a change in structure from wurzite to zinc-blend

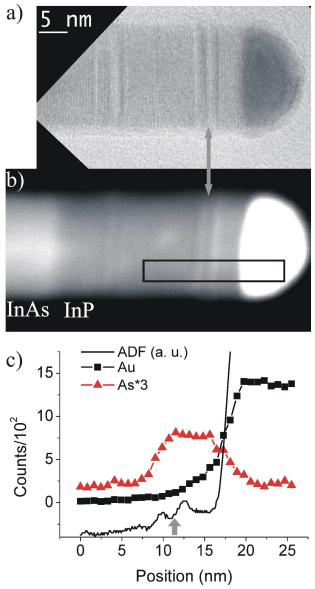

Figure 2: a) HRTEM image showing the change in structure. **b)** ADF (Annular Dark Field) image of the same region. **c)** ADF, EDS Au and EDS As profiles along the rectangle in **b)** showing that the change in structure and increase in As content are spatially correlated.

[1] L H G Tizei, T Chiaramonte, D Ugarte and M A Cotta, Nanotechnology, **20** in press (2009)