Growth mechanisms and kinetic instabilities in Au and Ag-catalyzed InP nanowires

Douglas S.Oliveira[1], Luiz H.G. Tizei[2], Daniel Ugarte[1] and **Mônica A. Cotta**[1]

[1]*Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas, Brazil*

[2]*Laboratoire de Physique des Solides, Université Paris-Sud, France*

monica@ifi.unicamp.br

Abstract:

Semiconductor nanowires (NWs) are currently under intense investigation, from the very basic understanding of formation mechanisms of these nanostructures to their possible technological applications. However, these different research lines share a common ground since understanding nanowire synthesis generally leads to new features and applications. As an example, the catalyst material can dramatically change the morphology of the nanowire, but under the right growth conditions it can be used as a parameter for both growth control and modeling. We report here results on the growth of Au and Ag-catalyzed InP nanowires, and discuss the precursor and temperature influence on the growth process in both cases. The microscopy analysis of the ensemble of our nanowires suggests that both vapor-liquid-solid (VLS) and vapor-solid mechanisms are present in our samples, giving rise to different nanowire morphologies and aspect ratios. We have proposed earlier that, for InP nanowire growth under high group III flows, there is a competition between different incorporation pathways of In atoms. This process may lead to a deformation on the triple- phase-line [1], and eventually to mechanical instabilities of the nanoparticle (NP) position on top of the nanowire. Crystallographic phase changes may occur in this case, as well as sidewall wetting by the NP material. Under these conditions, spontaneous diameter oscillations form along InP nanowires grown with Au nanoparticles [2]. The mechanical stability of the nanoparticle on the top of the nanowire depends on the surface energies involved in the problem. Thus changing the metal catalyst from Au to Ag, which has a lower surface energy, should alter the growth equilibrium conditions. Indeed, we observe different contact angles in this case. However, nanowire diameter oscillations are still achievable under different growth conditions than for the Au catalyst, suggesting these are general phenomena which occur under far from equilibrium conditions in VLS growth.

References

[1] Chiaramonte, T.; Tizei, L. H. G.; Ugarte, D.; Cotta, M. A., Nano Letters **11** (2011), 1934–1940
[2] Oliveira, D. S.; Tizei, L. H. G.; Ugarte, D.; Cotta, M. A., Nano Letters **13** (2013), 9–13

Figures:

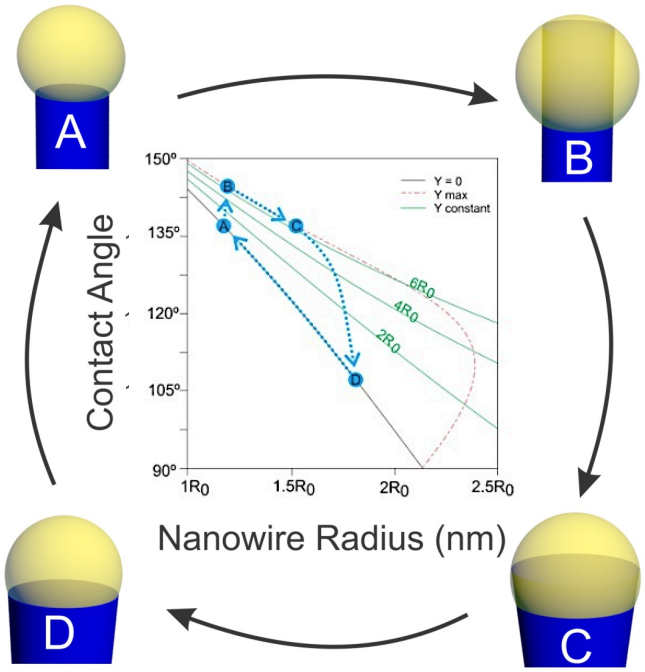

Figure 1 – Geometric model for NP mechanical instability due to TPL deformation and sidewall wetting; the associated catalytic radial growth and contact angle variation lead to periodical variations of nanowire diameter and phase changes [2].

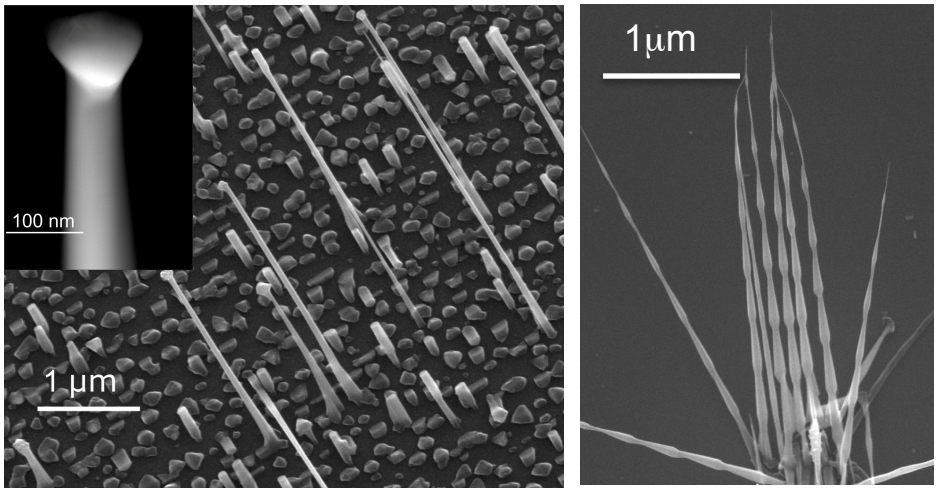

Figure 2 – Scanning electron microscopy images showing morphologies of Ag-catalyzed InP NWs grown under different growth conditions: large apex regions (left) and diameter oscillations (right).