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Constructing polytypism in semiconductor nanowires during growth: the case of silicon

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The VLS (vapour-liquid-solid) and VSS (vapour-solid-solid) modes of semiconductor nanowire (NW) growth present the possibility of naturally delivering metastable crystal polytypes directly, without any additional treatment [1-3]. The mechanisms, for that natural occurrence of out-of-equilibrium structures, are fairly well understood for compound semiconductors [4,5]. However, if such polytypes sometimes also appear in elemental semiconductor nanowires, like in very narrow SiNWs [3], they are much rarer, and the conditions for their growth remain unknown. We launched, three years ago, the "HexaNW" ANR project with the goal of understanding the occurrence of hexagonal polytypes in the case of SiNWs. As such polytypes had been obtained in NWs grown with Sn catalyst on a Cu substrate [3], we studied Cu-Sn alloy catalysts. As they were obtained using plasma-enhanced chemical-vapour-deposition (PECVD), we implemented an electron cyclotron resonance plasma source (Aura-wave from SAIREM) on the H_2 line of the "NanoMAX" *in situ* environmental transmission electron microscope (ETEM). We managed to obtain 2H domains in narrow SiNWs, both ex-situ in a standard PECVD reactor (Fig. 1) and in the NanoMAX ETEM, where we could watch the nucleation of that phase atomic plane by atomic plane. The aim of the talk is to present the main results of that project, with an emphasis on the NanoMAX movies of the growth.

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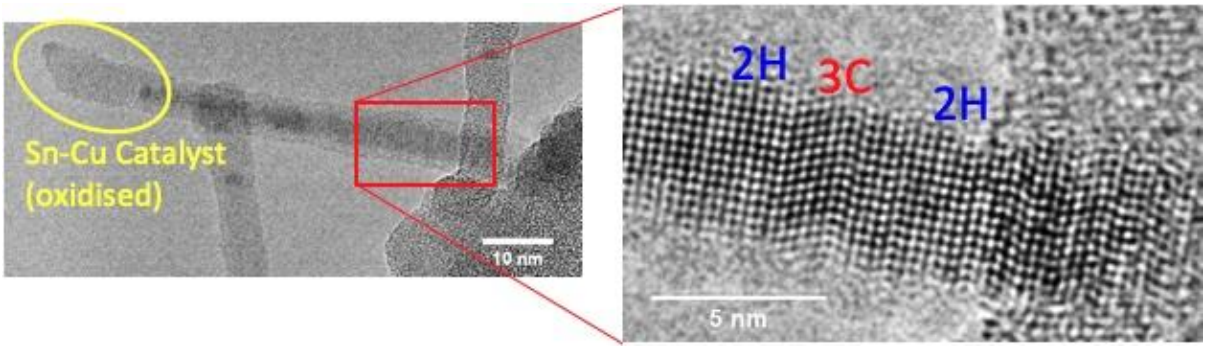

Figure 1: 2H SiNW obtained by PECVD, with a short 3C (cubic) domain.