Mechanistic study of formation of ultra-thin single crystalline Pt nanowire and its alloys

Samantaray, D.[1], Dipanwita, C.[2] and Ravishankar, N.[2]

[1] Materials Research Center, Indian Institute of Science, India

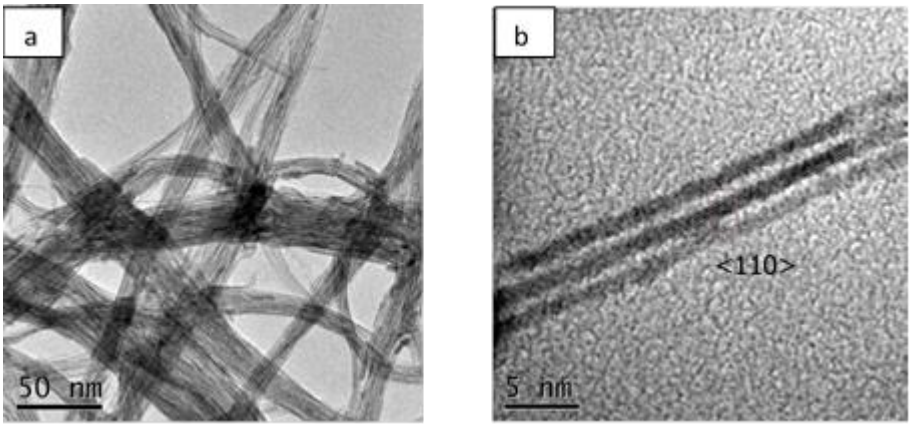
Wet chemical synthesis provides a simple and scalable route to synthesize nanomaterials with controlled size and shape. Tuning size and shape of nano crystal often leads to enhancement of various properties which are again very different from their bulk counterpart. Many exciting properties of the nanocrystals arise due to their higher surface area, hence qualifying them as excellent catalysts. Ultrathin nanowires with high aspect ratio provide very high surface to volume ratio. Moreover, noble metal nanowires are extremely important from fundamental and application point of view. However, anisotropic growth (1D here) in case of high symmetry material (specifically FCC crystal like Au, Ag, Pt) is not very straight forward to achieve. But, in these systems the inherent symmetry can be broken by using suitable capping agent or template [1]. Though ultra-thin Au nanowire of 2nm diameter has been synthesized and studied extensively, achieving Pt nanowire of such dimension remains challenging due to its intrinsic isotropic nature. Herein, we report synthesis and mechanism of ultrathin Pt nanowire which has been achieved via a simple solvothermal method without making use of any special atmosphere.

As synthesized Pt nanowires have a diameter of 2-3 nm and lengths in microns. HRTEM images of these wires confirm that these are single crystalline in nature and interestingly the growth direction is <110> which is different from that of Au nanowire, where the growth direction is <111>. To understand the formation and growth mechanism of these nanowires, several control experiments have been performed. TEM analysis of the quenched samples at an earlier stage reveals that initially bigger particles (7-8 nm) form which eventually break down to smaller monodispersed particles of size 2-3 nm. The breaking of larger particles to smaller ones (in presence of excessive capping agent) can possibly be attributed to digestive ripening. Further these monodisperse particles could undergo oriented attachment to form the 1D structure. It has been observed that the presence of capping agent plays a critical role in the kinetics of the reaction.

Since these nanowires are only few atoms thick, they show very interesting electrical transport property. Thermal stability of these wires has been studied by in situ TEM heating as well as ex situ heating. Moreover, these wires show superior thermal stability as compared to Au nanowire of similar dimension and hence can be used as a promising candidate for interconnects. These wires have been further converted to bimetallic nanowires like PtPd and PtCu by using Pt nanowire as template.

Reference:

1. Halder, A., Kundu, P., Viswanath, B. & Ravishankar, N. Symmetry and shape issues in nanostructure growth. *Journal of Materials Chemistry* **20**, 4763-4772 (2010).


a
50 nm
b
<110>
5 nm