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Mechanistic Studies of Growth of Ultrathin Pt and Alloy Nanowires

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Tuning shape and size of a nano crystals can manifold various physio-chemical properties, which in turn can also enhance their functionality as compared to their bulk counterpart. Many intricate properties of these colloidal nanocrystals arise as a result of their high surface to volume ratio. Ultrathin noble metal nanowires are interesting for numerous electronic and optical application apart from their superior catalytic performance. However, achieving anisotropic growth (1D) in case of FCC crystal like Au, Ag, Pt is extremely challenging due to their intrinsic symmetry. However, various symmetry breaking methodology has been successfully realized (especially in wet chemical method) by a judicious selection of capping agent1. Though ultra-thin Au nanowire2 of 2nm diameter has been synthesized3, but its poor thermal stability puts an experimental limitation on its application as nanoscale-interconnect. As an alternative, ultrathin Pt nanowire has been synthesized by a simple-wet chemical method. The unconventional formation mechanism of these nanowires has been studied by carrying out several control experiment and analyzing the time evolution products using Transmission Electron Microscopy (TEM). Further, using these nanowires as template, various bimetallic nanowires of PtCu, PtPd and magnetic nanowires like PtFe and PtCo has been synthesized. Ultrathin Pt nanowire has been achieved via a modified solvothermal4 method and are found to be single crystalline in nature with a diameter of 2-3 nm (fig:1b). HRTEM images of these wires confirm that these have a growth direction is < 110 > (fig:1c). To understand the formation mechanism of these ultrathin nanowires, several control experiments have been carried out. TEM analysis of the products at an earlier stage of reaction reveals that initially bigger Pt particles (7-8 nm) form, which then break down to smaller particles of size 2-3 nm. This can be attributed to digestive ripening5 mechanism, where bigger particles break down to smaller monodispersed particles in presence of excessive capping agent. In situ TEM heating of these ultrathin Pt nanowires show superior thermal stability as compared to ultrathin Au nanowire of similar dimension. Using these Pt nanowire as template, bimetallic nanowires of PtCu and PtPd have been synthesized, which show superior catalytic behavior towards methanol and ethanol oxidation. Alloying in these wires has been confirmed by carrying out elemental analysis using STEM-EDAX. In this work, formation mechanism of ultrathin single crystalline dispersed Pt nanowire has been studied which are few atoms thick. Time evolution of these ultrathin Pt nanowire has been studied suggests, growth of Pt particle followed by digestive ripening and subsequent alignment to form nanowire. Moreover, magnetic nanowires like FePt and CoPt have been synthesized using the Pt nanowire as template.

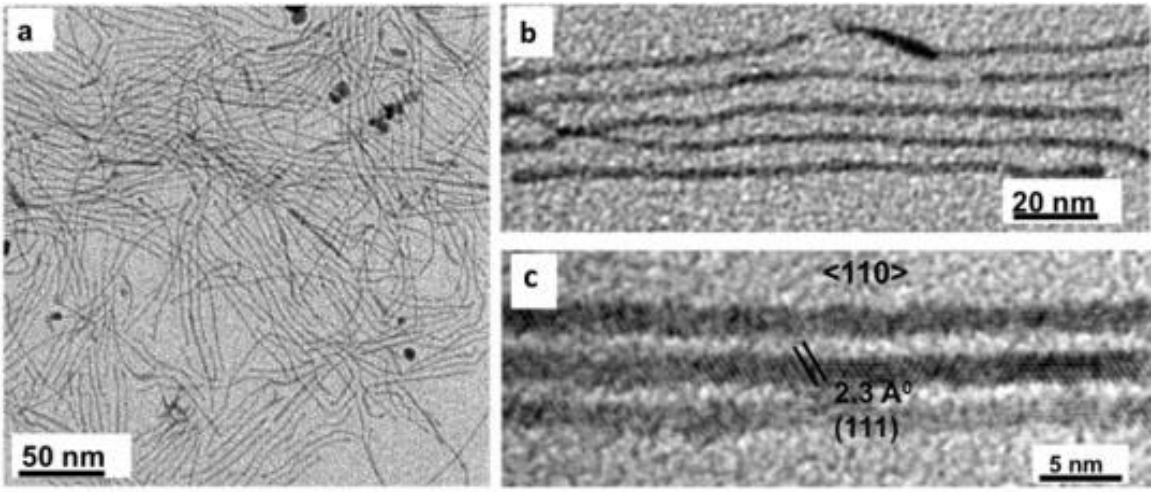

Figure 1. Fig:1(a) depicts low magnification TEM image of Pt nanowires, (b,c) correspond to high magnification and HRTEM image of the Pt nanowires respectively.

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