Ultrathin Au-Alloy Nanowires: Exploring their Structure and Chemistry at the Atomic Scale

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Tuning the morphology, crystalline nature and architecture of nanostructures enables us to explore fundamental science as well as applications. Wet chemical synthesis is the easiest and most convenient tool for nanostructure engineering. 1-D nanostructures in the form of ultrathin nanowires show interesting and unexpected behavior and a fascinating range of properties that are different from their bulk counterparts. It is tricky to design the growth of such kinetically unfavorable anisotropic structures. Ultrathin (~2 nm dia) Au nanowires have found quite interesting applications in various devices and as catalytic materials. However, Au nanowires are very fragile and difficult to handle. Their versatility could be further enriched if they can be made more stable. In this work[1], we have explored conversion of the Au nanowires into thermally and mechanically more stable alloy nanowires while maintaining the morphology. We have also explored the conditions of growing these alloy nanowires on 1-D and 2-D oxide supports to build interesting heterostructures with important applications in the field of catalysis.

We have converted Au nanowires into alloy nanowires by reducing the second metal (M= Cu/Pd/Pt) precursor on the template Au nanowires. Since Au nanowires are unstable in polar solvents and at temperatures beyond 80^{o}C, it is difficult to reduce the M precursor on Au nanowire template. To overcome the challenges we have introduced a unique design of reaction at the liquid-liquid interface to keep Au nanowires template intact as well as use extreme conditions for reduction of M precursor on Au template. The alloy nanowires are ~3.6 nm in diameter and inherit the crystallography from the parent Au nanowires, as can be seen in fig 1(a) and (b). STEM-EDS mapping in fig 1(c-e) shows the presence of Au and M along the length of the wires, confirming alloying. Thermal stability experiments have shown the AuPt and AuPd wires survive up to 200^{o}C in air and presence of twin boundary and stacking fault defects improves the mechanical stability of the wires. This opens up avenues for wider range of application and fundamental studies on the ultrathin alloy nanowires which were not possible on Au nanowires due to its fragility. Using this synthesis method we have also grown alloy wires of different compositions. To further expand the possibilities of application of the ultrathin alloy nanowires in the fields of heterogeneous catalysis we have devised growth of alloy nanowires on graphitic oxide sheets, ZnO nanorods and Si wafers. Results on growth and detailed understanding of structure and composition using electron microscopy will be presented.

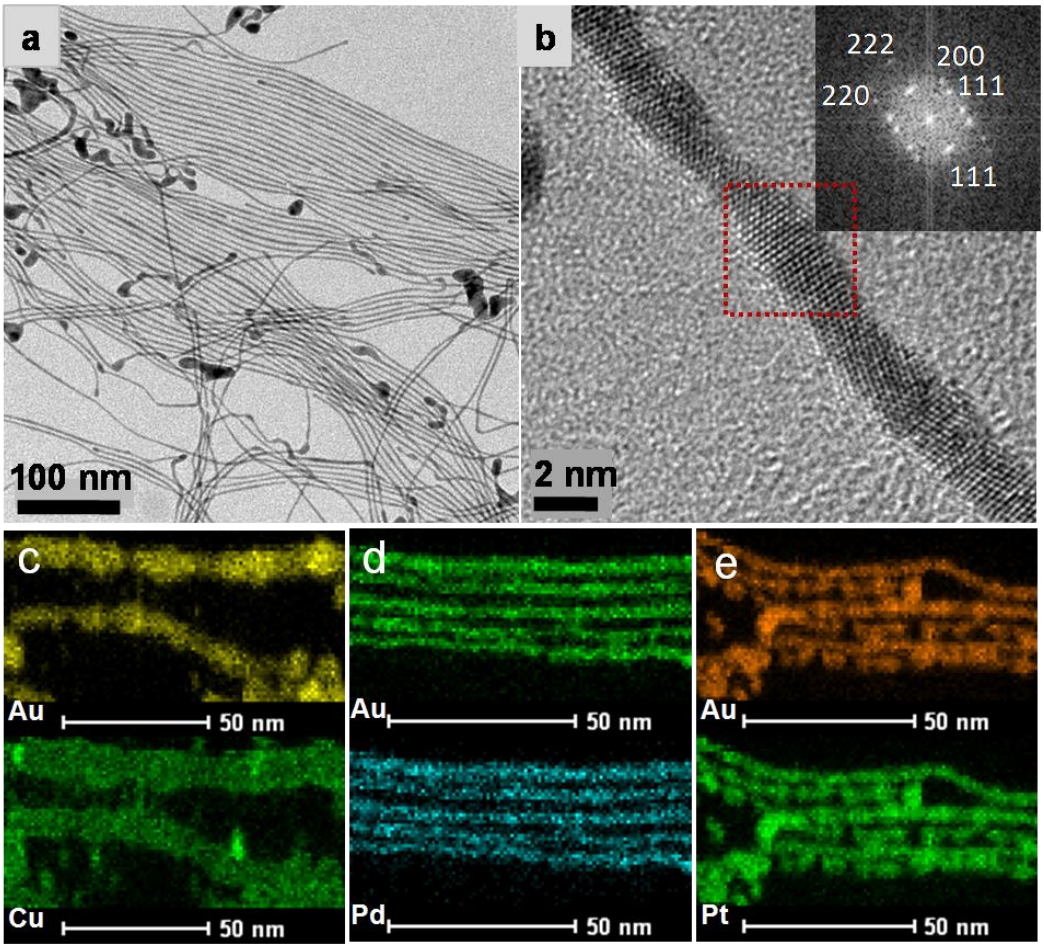

Figure 1. Representative low magnification and high resolution TEM images of AuM (M= Cu/Pd/Pt) alloy nanowires are shown in (a) and (b) respectively. HAADF-STEM EDS mapping of the alloy nanowires are shown in (c-e).

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Reference:

1. Dipanwita Chatterjee; Shwetha Shetty; Knut Müller-Caspary; Tim Grieb; Florian F. Krause; Marco Schowalter; Andreas Rosenauer; N. Ravishankar, Ultrathin Au-alloy Nanowires at the Liquid-Liquid Interface. *Nano letters* **2018**.