Electrochemical synthesis of Au, Pt and AuPt nanowires and its characterization

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Abstract

Monometallic nanostructures like Au and Pt have been the focus of passionate research both from a chemical and electrochemical perspective due to their potential applications in various fields including the design of mobile catalytic nanowires for targeted drug delivery. Bimetallic nanostructures, in particular, Pt-based nanostructures have been reported to exhibit good performance as electro catalysts in liquid fuel cells and are regarded as an alternative to commercial catalysts. In particular, AuPt nanowires are potential candidates with application as nanomotors. The self-organized anodization of aluminium, which results in a pattern of nanopores with an extended long-range perfect order is a very promising powerful and inexpensive method used for the synthesis of nanostructured materials. Anodic aluminum oxide (AAO) templates are widely used for the transfer of nanopore arrangements to other materials. Further, AAO template assisted nanowire growth has numerous advantages as compared with other methods such as simplicity, low cost of processing, easy material handling and ability to tailor size, chemical composition, and microstructure of nanowires with desired properties.

Here, a range of nanowires of Au, Pt and AuPt were deposited by electrochemical deposition (potential sweeping) method using AAO templates with pore size 200 nm. We prepared Au, Pt and AuPt nanowires (~200 nm diameter x ~3-4 µm length) via cyclic voltammetry experiments using an electrochemical work station (CH Instruments Inc. 1750 A) from corresponding metallic salt solutions. Free standing nanowires were obtained by dissolving the alumina template in 3M NaOH for 30 minutes. A Pt wire was used as the counter electrode and Ag/AgCl electrode was used as the reference electrode. A thin layer (~20-30 nm) of sputtered Au/Pd (target containing 90% Au and 10% Pd) on the branched side of AAO template served as working electrode contact. Other materials like C, Ag and Al were also employed for coating the template prior to electro deposition in order to evaluate the effect of AAO coating on the deposition of nanostructures. A detailed study revealed that the type of substrate coating material have a significant influence on the nanostructure formed either in terms of its shape or quantity of nanowires formed.

Confirmation of the presence of Au and Pt was achieved using cyclic voltammetry (CV) while SEM (JEOL JSM 6390 LV) and EDX was employed in order to examine the morphology and structural composition. SEM and EDX measurements were performed on nanowire deposited AAO templates as well as on Si substrate.

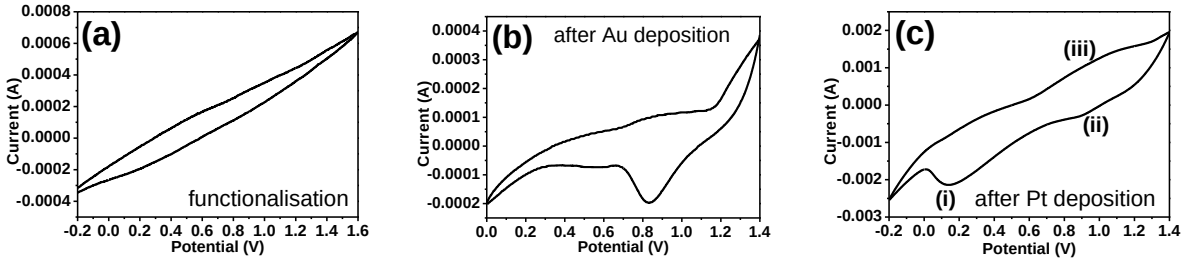

Figure 1 (a) A typical plot which shows the acid functionalisation (activation) of porous alumina membrane using potential sweeping for 4 cycles at 0.1 Vs^{-1} in 0.5 M H_2SO_4 vs. Ag/AgCl **(b) & (c)** A typical plot which shows Au and Pt deposition confirmation, respectively on functionalised alumina membrane using 0.5 M H_2SO_4 at 0.1 Vs-1 for 20 cycles.

Fig. 1 (a) shows the typical CV plot during the AAO template functionalisation. Fig. 1 (b) and (c) depicts the CV plot measured with Au and Pt deposited AAO template respectively, confirming the Au and Pt deposition on the AAO template. The peak at ~0.8 V in figure (b) represents the Au peak. From figure (c), the peak at ~0.1 V (i) and the broad band at ~1.1 V (ii) can be attributed to hydrogen adsorption and Pt oxide reduction respectively. Whereas the broad band at ~1 V (iii) is due to Pt oxidation.

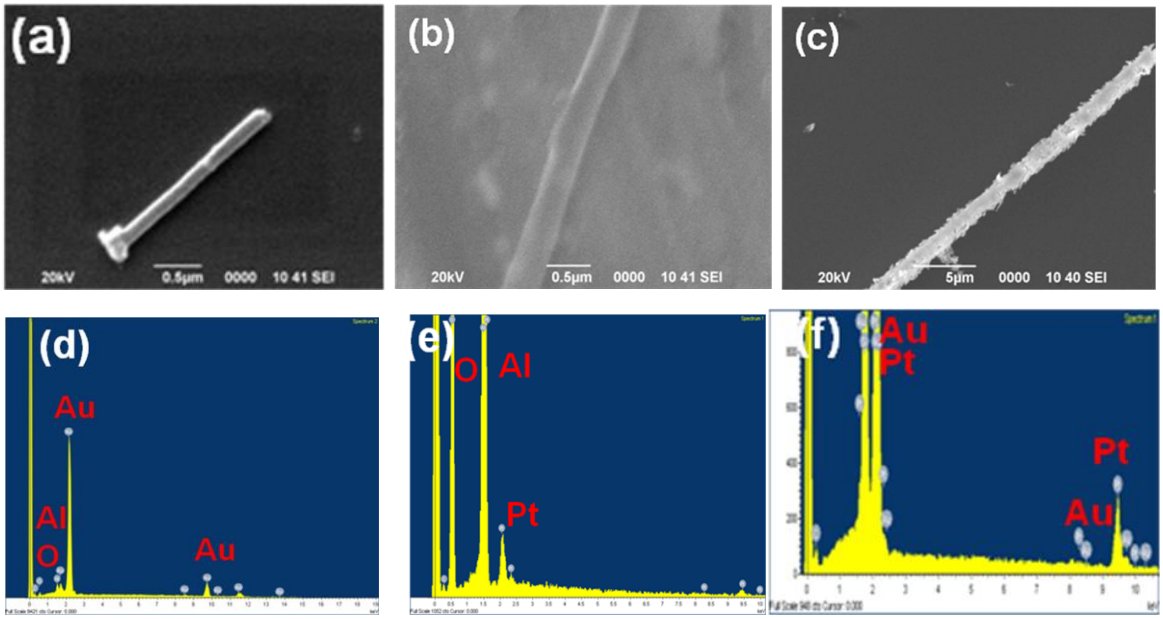

Figure 2 (a), (b) & (c) SEM of the typical Au, Pt and AuPt nanowire on Si substrate **(d), (e) & (f)** EDX from SEM image (a), (b) & (c) showing the metal composition.

Fig. 2 (a) to (c) demonstrates the SEM images of Au, Pt and AuPt single nanowires on Si substrate after dissolving the AAO template in 3 mM NaOH solution. EDX spectra obtained from the corresponding SEM images confirmed the growth of the Au, Pt and AuPt nanowire. The growth of AuPt nanowires were realized by depositing the Au first followed by Pt sequentially. Systematic study showed that the potential limits, scan rate, the concentration of the metallic salt solutions and charge passed had a significant influence on the nanostructures formed in terms of shape and quantity.

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