ELECTROCHEMICAL SYNTHESIS AND CHARACTERIZATIONS OF VERSATILE NANOWIRES

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Introduction and objective

Multisegment nanowires are interested because of their potential applications, e.g. chemical sensor, catalyst, products identification and biotechnology. However, the preparation process is time-consuming involving multiple plating steps from different metal solutions. This work proposed the use of single plating solution for single- and multi-segment alloy nanowires. In addition step-like porous gold nanowires were also prepared from etching electro-active component of multi-segment alloy nanowires. These nanowires showed the ability to be applied for product tracking. Composite material of step-like porous gold and polymer was also synthesized leading to attractive material for nano-hardware.

Methods

Alloy nanowires were prepared using template-assisted electrodeposition technique of the metal-mixture plating solution. Mixture of cobalt (Co), nickel (Ni) and copper (Cu) was used for single-segment nanowires by applying a constant deposition potential at -1.4 V and changing metal concentration to synthesize alloy nanowires of various compositions. Silver (Ag) and gold (Au) were used for multi-segment and step-like porous gold nanowires. By changing deposition potential between -0.5 to -1.2 V various compositions of Au/Ag in each segment can be achieved. For step-like porous gold nanowires the deposition potential was varied from -0.9 to -1.1 V followed by the dealloying of silver composition via acid etching to obtain porous structure. Finally, for all nanowires preparation, the template was dissolved to obtain free standing nanowires. Composition profile of single-segment alloy nanowire, qualitatively and quantitatively, was detected by X-ray fluorescence (XRF) whereas optical reflectivity was used to qualify the multi-segment alloy nanowires. These can be interpreted to be coding pattern. Energy dispersive X-ray fluorescence (EDX) was used to study the % atom of gold and silver at different deposition potential for multi-segment and porous gold nanowires. Scanning electron microscope (SEM) was used to study the pore distribution, the diameter of porous gold at different composition of gold/silver and the characteristic of all nanowires.

Results

In single-segment alloy nanowires, different concentrations of Co, Ni and Cu in the plating solution provided different distinguishable XRF signatures corresponding to the metal concentrations. In case of multi-segment alloy nanowires, tuning the deposition potential from -0.5 to -1.2 V provided different Au-Ag compositions resulting in different light reflectivity. From EDX study silver decreased from 92 to 53% in the studied range. The reflectivity of multi-segment alloy nanowires can be distinguished up to 5 intensity levels. Thus, various encoding patterns can be generated for product tracking. For the step-like porous gold nanowires, applying different deposition potential from -0.9 to -1.1 V changed the composition of Au-Ag from 15% atom of gold (-0.9 V) to 85% (-1.1 V). Different diameters were obtained at different % atom of gold. The normalized diameter of step-like porous gold was calculated with respect to solid gold segment and ranged from 65.0 to 88.7%. Nanowires containing composite material between porous gold and polypyrole were also synthesized. The SEM images in Figure 1 presented the single- (A) and multi- segment (B) alloy nanowires, the step-like porous gold (C) and step-like porous gold/polymer composite nanowires (D). These micrographs illustrated the ability to tailor the composition and shape of the nanowires for bar-codes application and nano-devices.

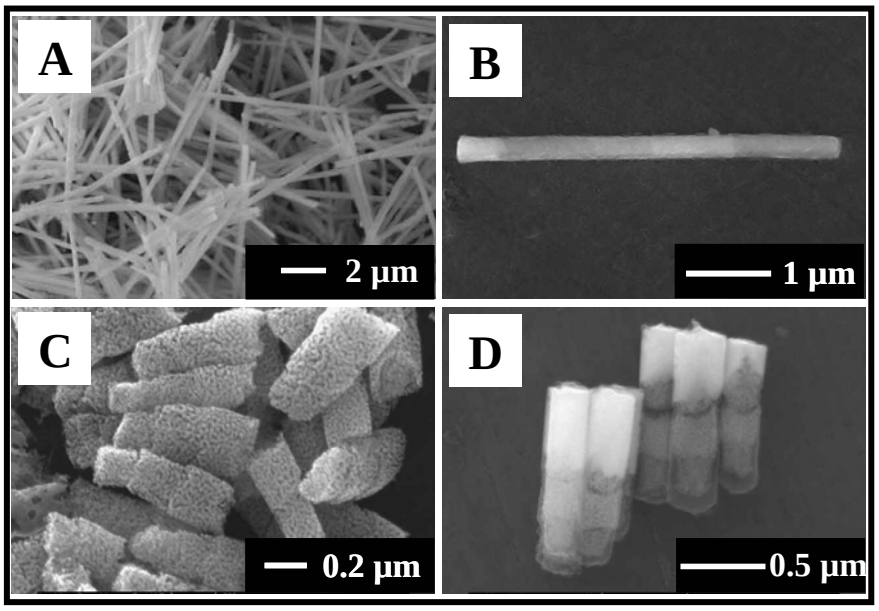

Figure 1 SEM images of nanowires prepared from single plating solution (A) single segment alloy nanowires (B) multisegment alloy nanowires (C) step-like porous gold nanowires (D) step-like porous gold/polymer composite nanowires

Conclusions

The template-assisted electrochemical technique with a single plating solution was successfully developed for single- and multi-segment alloy nanowires barcodes and step-like porous gold nanowire. XRF and optical reflectance are effective readout techniques of alloy nanowires. SEM illustrated the step-like porous gold and also composite material. These versatile composition- and shape- tailored concept can be extended to nanowires which have diverse properties based on different metals and also composite material. These production can be used for a wide range of application *i.e.,* product tagging and nano-devices.

Keywords: Alloy nanowire barcodes, Step-like porous gold, Composite Au/PPy, Electrodeposition

Selected References:

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