CONTROLLED FABRICATION OF LARGE ARRAYS OF POLY- AND SINGLE-CRYSTALLINE GOLD NANOWIRES

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Metallic nanowires are of great interest for future applications in fields such as electronics, optoelectronics, chemical and biological sensors, and magnetic and electromechanical devices [1, 2]. In particular, gold nanowires are very attractive because of excellent electrical, thermal and oxidation-resistance properties. The features of the nanowires depend strongly on their crystalline structure. It is therefore important to fabricate nanowires with well-defined crystallographic orientations. We report here the synthesis of Au nanowires by electrochemical deposition in nanoporous ion track membranes. We show that the texture of the wires can be controlled via the deposition parameters governing the fabrication process.

The nanoporous etched ion-track templates are prepared in two steps: (i) heavy-ion irradiation of polycarbonate foils (thickness 30 μm) at the UNILAC linear accelerator of GSI, (ii) etching of the latent ion tracks in 6 M NaOH at 50°C. The diameter of the etched pores, which determines the diameter of the nanowires synthesized inside, is controlled by the etching time. A conductive layer deposited on one side of the membrane and a platinized titanium wire act as cathode and anode, respectively, during the electrochemical growth of the wires [3, 4]. The effect of various parameters (deposition voltage, working temperature and electrolyte) on the Au deposition was investigated. Transmission electron microscopy (TEM), selected-area electron diffraction (SAED) and X-ray diffraction (XRD) were used to investigate the crystallographic structure of the wires. The wire morphology was studied by scanning electron microscopy (SEM).

We found that both applied voltage and working temperature strongly influence the wire texture. We obtained highly textured single-crystalline nanowires by using elevated temperatures, low deposition voltages and a commercial potassium dicyanoaurate(I) electrolyte. A HRTEM micrograph of a gold nanowire deposited with the cyanide electrolyte using DC deposition (U = 900 mV) at 65 °C is shown in figure 1(a). The inset shows the SAED pattern corresponding to single-crystallinity. Figure 1(b) represents the XRD measurements performed on a wire array of the same sample (while being still embedded in the polymer foil). The result confirms that the nanowires are single-crystalline and highly textured. Both the SAED and XRD results visualize that the growth direction of the wires is [110].

Fig. 2(a) displays a SEM image of Au nanowires with diameter 70 nm after dissolution of the membrane in CH_2Cl_2. The SEM images indicate that all wires possessed a very homogeneous contour and cylindrical shape. We found that the cap forming on top when a wire grows out of the template strongly evidences the particular wire crystallinity. Caps grown on the top of polycrystalline wires exhibit hemispherical shapes (Fig. 2b), while those on single-crystalline wires display facetted forms (Fig. 2c).

References:

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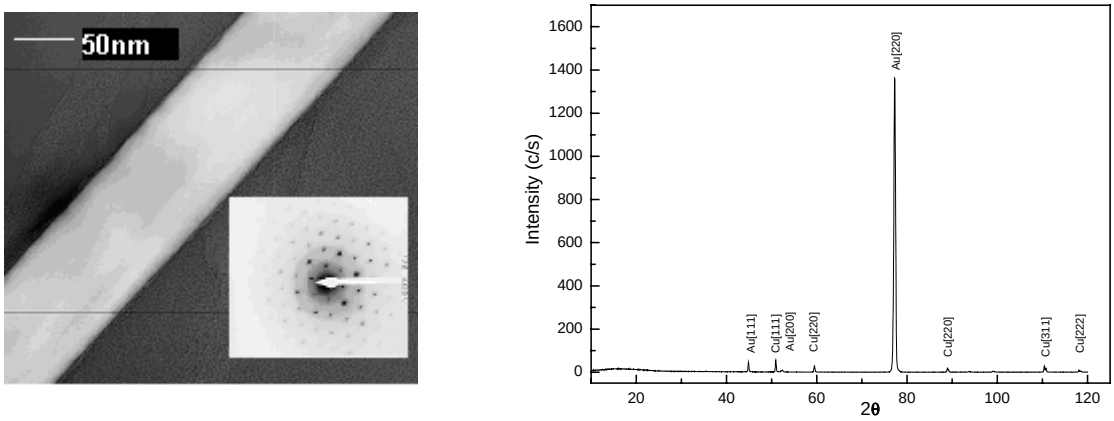
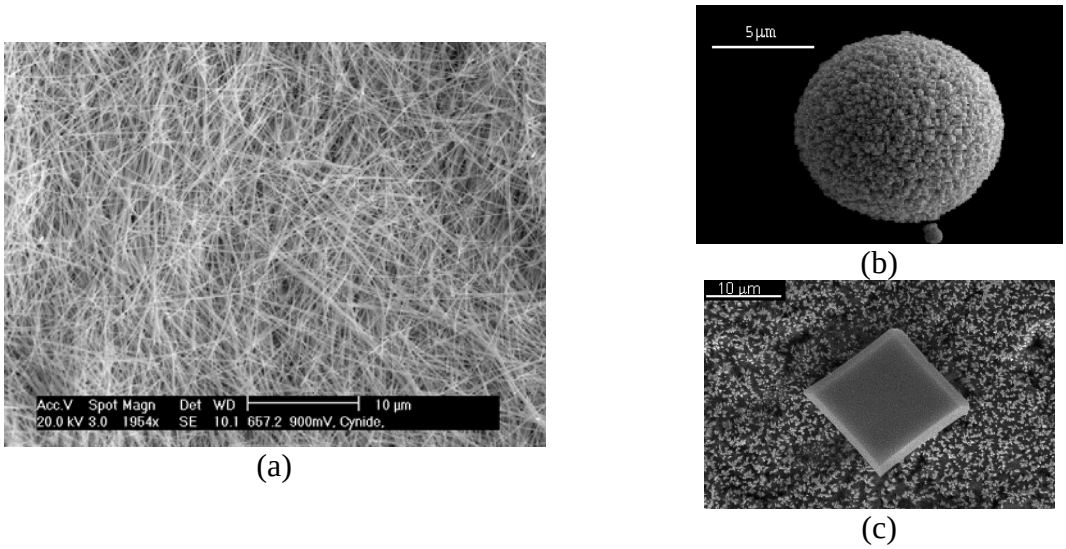
Figures:



(a) (b)

Figure 1 (a) HRTEM image of a single-crystalline gold nanowire, with its corresponding SAED pattern (inset), (b) XRD pattern of the Au nanowire array.



(a) (b) (c)

Figure 2 SEM micrographs of (a) Au nanowires with diameter 70 nm after dissolution of the template, (b) hemispherical polycrystalline cap, (c) facetted single-crystalline cap.