Supplementary Material (ESI) for Chemical Communications

Supporting Information for

Cold-welding Fabrication of Highly Ordered Gold Nanochannel Monolayers in Aqueous Medium

Yingpu Bi and Jinhua Ye *

International Center for Materials Nanoarchitectonics (MANA), and Photocatalytic Materials Center, National Institute for Materials Science (NIMS), 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan

*To whom correspondence should be addressed.

Email: jinhua.ye@nims.go.jp

Experimental Section

1. Synthesis of rectangular silver nanowires

The silver nanowires were prepared by a modified polyol process. In a typical synthesis, 1, 2-Propylene glycol (1, 2 PG, 10mL) that contained poly (vinyl pyrrolidone) (PVP, $M_W \approx 50000$, 150 mM as calculated in terms of the repeating unit) was placed in a 25-mL vial, capped, and heated with stirring in an oil bath at 160 °C for 1 h. 1 mL NaCl solution (1 mM in 1, 2 PG) was then quickly added. After 5 min, $AgNO_3$ (0.15 M solution in 1, 3 BG) were added with drop by drop to the stirring solution. The vial was then capped and heated at 160 °C for 40 min. After injection of the $AgNO_3$ solution, the color of reaction mixture changed from milkiness to light yellow, and silvery white. After synthesis, the wire solution was cooled to room temperature.

2. Synthesis of rectangular silver nanowire arrays

The above samples were diluted in a 1:10 ratio with water and stirred strongly for 20 min. After that, the dilute nanowire solution kept stillness for 3 hours, then the silver nanowires deposited on the bottom of vessel and upside solution containing ployols, silver nanoparticles, and excess PVP has been removed. This process was repeated approximately four times. With this simple process, it can be clearly seen that the silvery-white film have been formed on the surface of water. This film was transferred into another beaker for synthesizing of gold nanochannel monolayer.

3. Synthesis of gold nanochannel monolayer

In a typical synthesis of Au nanochannel monolayer, the reaction solution containing the as-synthesized Ag nanowire arrays was added to 20 mL saturated NaI aqueous solution. Aqueous $HAuCl_4$ (0.02M) was slowly added dropwise to the above Ag nanowires solution. The resulting mixture was maintained at the room temperature until its color became golden. The obtained samples for morphology and structure analysis were washed with water and ethanol removes AgI precipitation and NaI via centrifugation. HNO_3 solution treatment was performed in order to remove the remnant Ag. Finally, the obtained Au samples were dissolved in the ethanol.

4. Electrochemical activities

Electrochemical activities of Au nanochannel monolayers were measured by cyclic voltammetry method using a standard three-electrode cell at the computer-controlled CHI660D electrochemical workstation. Two milligram of catalysts was suspended in 2 mL distilled water, the mixtures were ultrasonically scattered for 15 min to form homogeneous solution. Then, 5 μL solution was dropped on the glassy carbon (GC) electrode (3 mm diameter, 0.0706 cm^2). After evaporation of the water in air, 5

μL of a 1 wt% nafion solution (diluted from 5 wt% nafion with water) was transferred onto the electrode surface to attach the catalyst particles to the GC electrode. A Pt wire and saturated calomel electrode (SCE) were used as the counter and reference electrode, respectively. Formaldehyde oxidation experiment was measured in a solution of 1M KOH at room temperature. For all experiments the sweep rate was $50mVs^{-1}$.

5. Characterizations

The transmission electron microscopy (TEM) images were obtained on a transmission electron microscope (JEM-2100, JEOL) with an accelerating voltage of 160 kV. A drop of the solution containing samples was put onto a carbon-supported copper mesh, which was dried at room temperature. FE-SEM images were taken using a field-emission scanning electron microscope (JSM-6701F, JEOL) operated at an accelerating voltage of 15 kV. An energy-dispersive (ED) detector was equipped with this field-emission scanning electron microscope and operated at an accelerating voltage of 15 kV. The X-ray diffraction spectra (XRD) measurements were performed on a Philips X' pert MPD instrument using Cu Kα radiation (50 kv). The XRD patterns were recorded from 10° to 90°with a scanning rate of 0.067°/ s.

Additional Figures

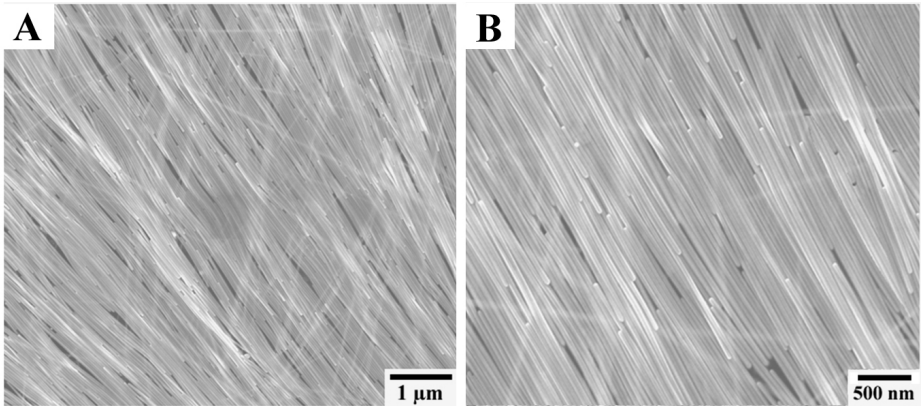

Fig. S1. (A-B) SEM images of silver nanowire monolayers.

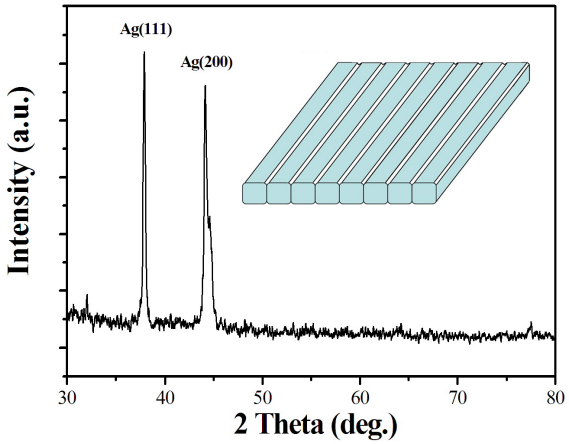

Fig. S2. XRD pattern of Ag nanowire monolayers.

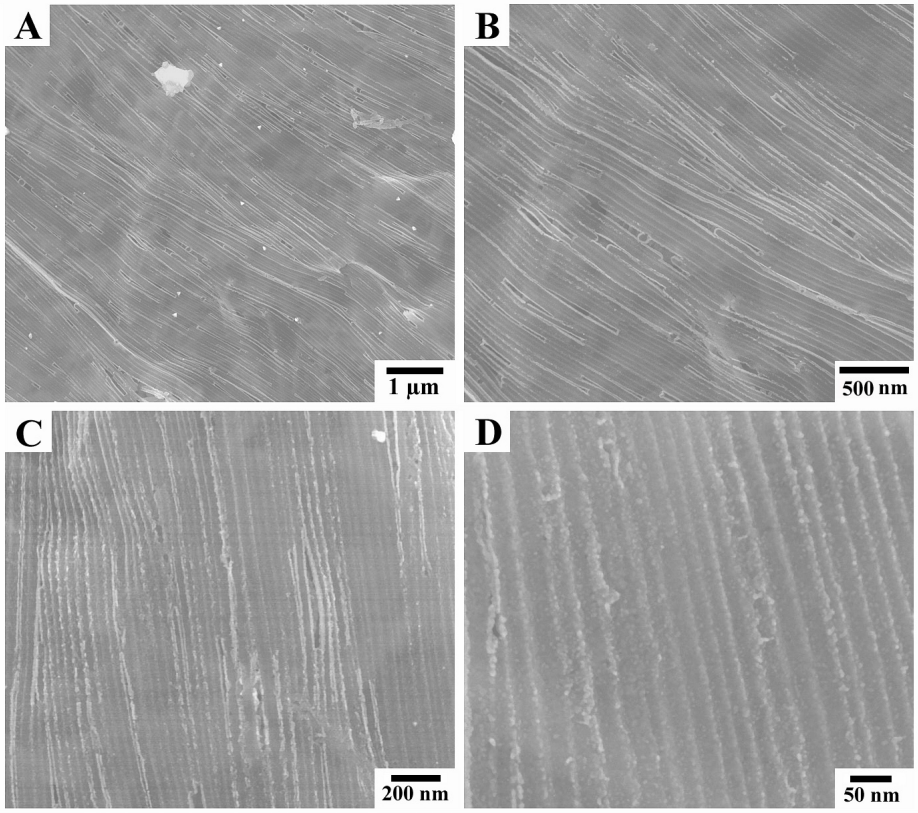

Fig. S3. (A,D) SEM images of Au nanochannel monolayers with different magnification.

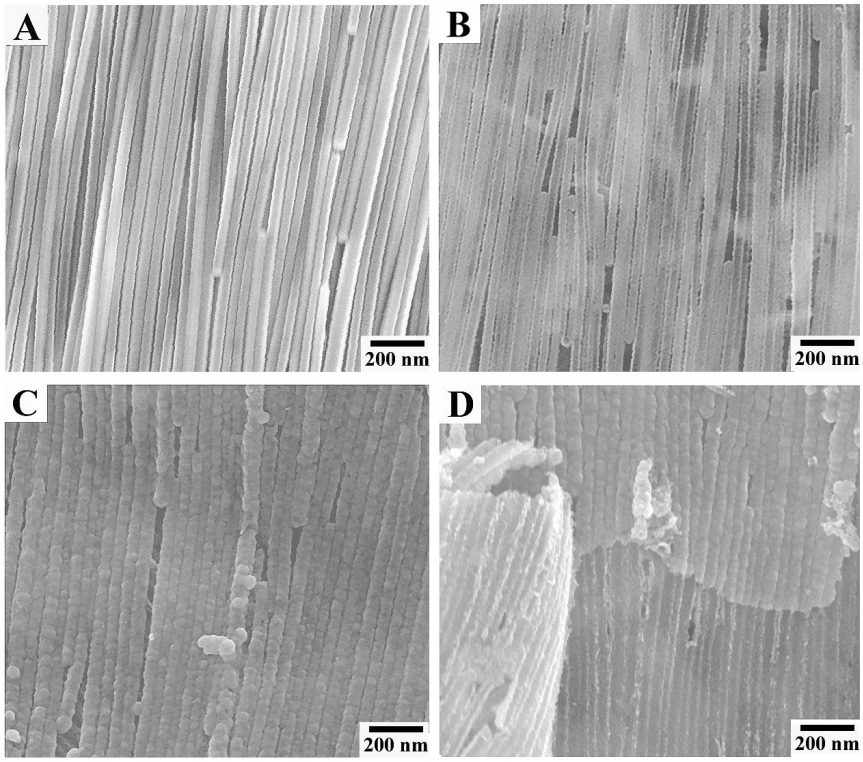

Fig. S4. SEM images of the Ag nanowire monolayer titrated with different 0.02M $HAuCl_4$. (A) 0 mL; (B) 1 mL; (C) 2 mL; (D) 2 mL.

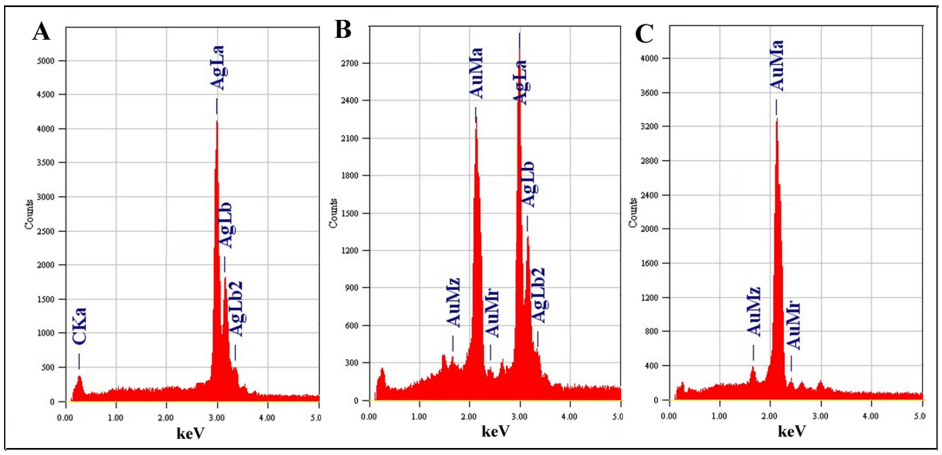

Fig. S5. EDS patterns of the as-synthesized products with different 0.02M $HAuCl_4$. (A) 0 mL; (B) 1 mL; (C) 2 mL.

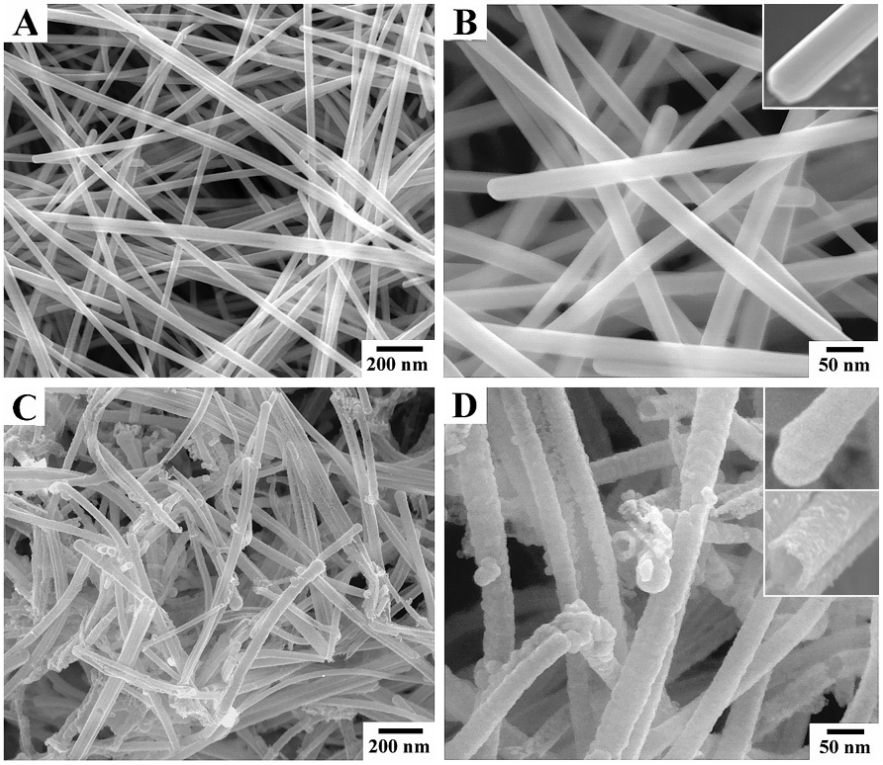

Fig. S6 (A-B) SEM images of disordered Ag nanowires, (C-D) SEM images of Au nanoproducts obtained by the galvanic replacement reaction with disordered Ag nanowires.

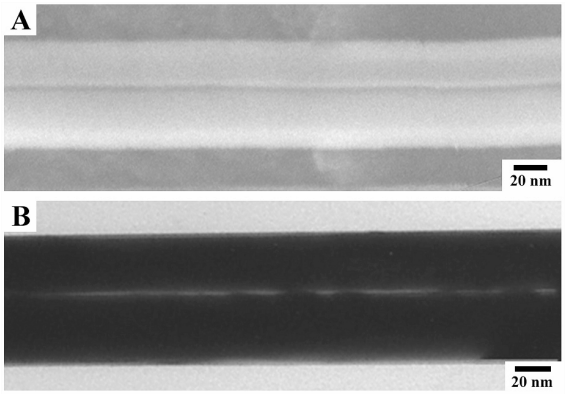

Fig. S7. (A) SEM images and (B) TEM images of two aligned Ag nanowires.

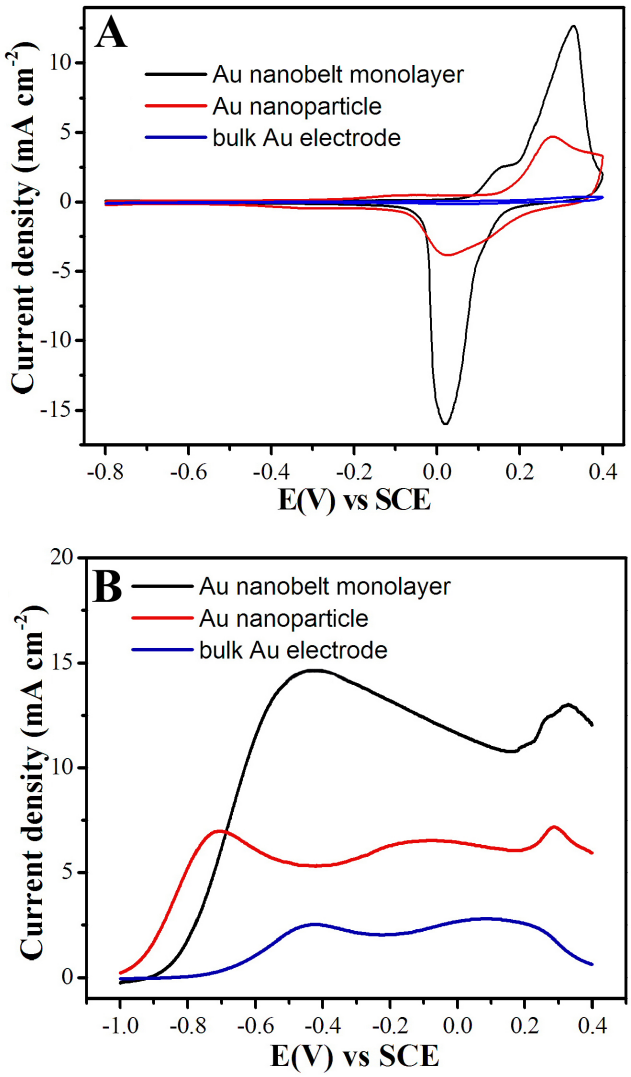

Fig. S8. (A) CV curves of Au sample in N_2-saturated 1.0 M KOH. (B) Electrocatalytic activity of various Au samples for HCHO oxidation under same conditions. Scan rate 50 mVs^{-1}.