Synthesis of Metallic Nanowires Using Hydrothermal Method

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Abstract

Silver nanowire grow on FTO coated quartz substrate by using hydrothermal method, it can be observed that the morphology of the product is wire-like and nearly uniform in width (60 ± 10 nm), while the length is in a relatively broad range (from 0.2 to 4 μm) with an average at 2.5 μm. The calculated lattice constant according to the (111) peak is 4.08 Å which is closely consistent with the standard value (4.086 Å).

Keywords: Ag nanowire; SEM; Structure properties.

تحضير ودراسة خصائص الهيدروكسيل-ابتايت النانوي باستخدام طريقة كيميائية

الخلاصة:

في هذا البحث تم تحضير مادة الهايدروكسيل-ابتايت الطبيعي باشكال واحجام نانوية مختلفة وذات سمية قليلة لغرض استخدام المادة في تطبيقات وذلك باستخدام طريقة كيميائية. من خلال دراسة السطح للمادة المحضرة وجد انها تكون باشكال كروية وقضيب ذات طول يتراوح بين 10-20 nm واقطار اقل من 10 nm .

INTRODUCTION

One-Dimensional (1D) nanostructures of metals play an important role as both interconnects and active components in fabricating nanoscale electronic devices. They also provide an ideal model system to experimentally investigate physical phenomena such as quantized conductance and localization effects [1]. Silver has been widely used as a conductive material due to its high electrical conductivity. Different shapes of silver, such as nanoparticle, nanorod, etc. have been synthesized under different reaction conditions, and silver NW is also an example [1, 2]. Silver nanowires have been attracting more and more attention because of their intriguing electrical, thermal, and optical properties. Silver has the highest electrical conductivity (6.3×10^7 S/m) and thermal (429 $W \cdot m^{-1} \cdot K^{-1}$) conductivities among all the metals, by virtue of which Ag NWs are considered as very promising candidates in flexible electronics [3]. Many chemical techniques have

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been proposed to control the formation and growth of 1D Ag nanowires, including photochemical, electrochemical, template-directed, and wet-chemical methods [4, 5]. Metallic nanostructures have a wide range of properties and applications. These properties and applications are determined by the shape, size, structure, and composition of the nanostructures. The presence of various ions has been shown to influence the shape and size of metallic nanostructures [6].

Experimental Method

Ag nanowire-like vertically aligned grow on FTO coated quartz substrate by using hydrothermal method. A template Ag thin film with a 350 nm thickness was deposited as a seed layer on FTO coated quartz substrate. Next step process, Ag nanowire-like were grown on Ag seed layer coated FTO-coated quartz substrate by hydrothermal method, which are 50 ml aqueous solution included silver nitrate and polyvinylpyrrolidone (PVP) were dissolved in distilled water with continuous stirring for 30 minutes in a glass beaker without heating (at room temperature) until the mixture solution became transparent. The effect of addition $FeCl_3$, NaCl, CuCl and Na_2CO_3 as salt solution to the above mixture solution were investigation in this work at room temperature. Then, the solution transferred into an sealed Teflon lined autoclave was kept in a laboratory oven at a constant temperature of 180 ^oC for 8 hr. After the complete reaction, the autoclave cooled down naturally and gradually. Finally, Ag NWs products grow on FTO coated quartz substrate were dipped carefully in ethanol and stored in air at room temperature.

Surface morphologies obtained through Scanning Electron Microscope (SEM) study carried out by (Hitachi model S-4160, Japan-daypetronic company) in Tehran country at 15 kV of Ag nanowire. The structure and lattice parameters of Ag NWs and Cu nanosheets are analyzed by a LabX XRD 6000 SHIMADZU XR – Diffractometer with Cu Kα radiation (wavelength 1.54059 Å, voltage 30 kV, current 15 mA, scanning speed = 4 °/min).

Results and Discussion

Figure (1) (a, b, c, d) show SEM pictures, it can be observed that the morphology of the product is wire-like and nearly uniform in width (60 ± 10 nm) while the length is in a relatively broad range (from 0.2 to 4 μm) with an average at 2.5 μm. The software used in calculation of this work was MBF_Image J. program figure (1) (a) shows the menu bar of this program. It is a public domain Java image processing program inspired by NIH Image for the Mac-intosh. It runs, either as an online applet or as a downloadable application, on any computer with a Java 1.1 or later virtual machine. This program has the ability to find and measure the dimensions in either nano or micro scale and make a comparison with a known scale from a specific image, such as SEM images or optical micrometer images. The effect of salt solution on resulting diameter of silver NW is summarized in figure (1) (c, d). The diameter decreased from 60 nm when no chloride ion was added in the second step to about 40 nm The effect was very significant when the quantity of chloride addition was small, and it became negligible. The NW diameter stopped decreasing, suggesting the saturation of adsorption and indicating that both ions are necessary for wire growth.

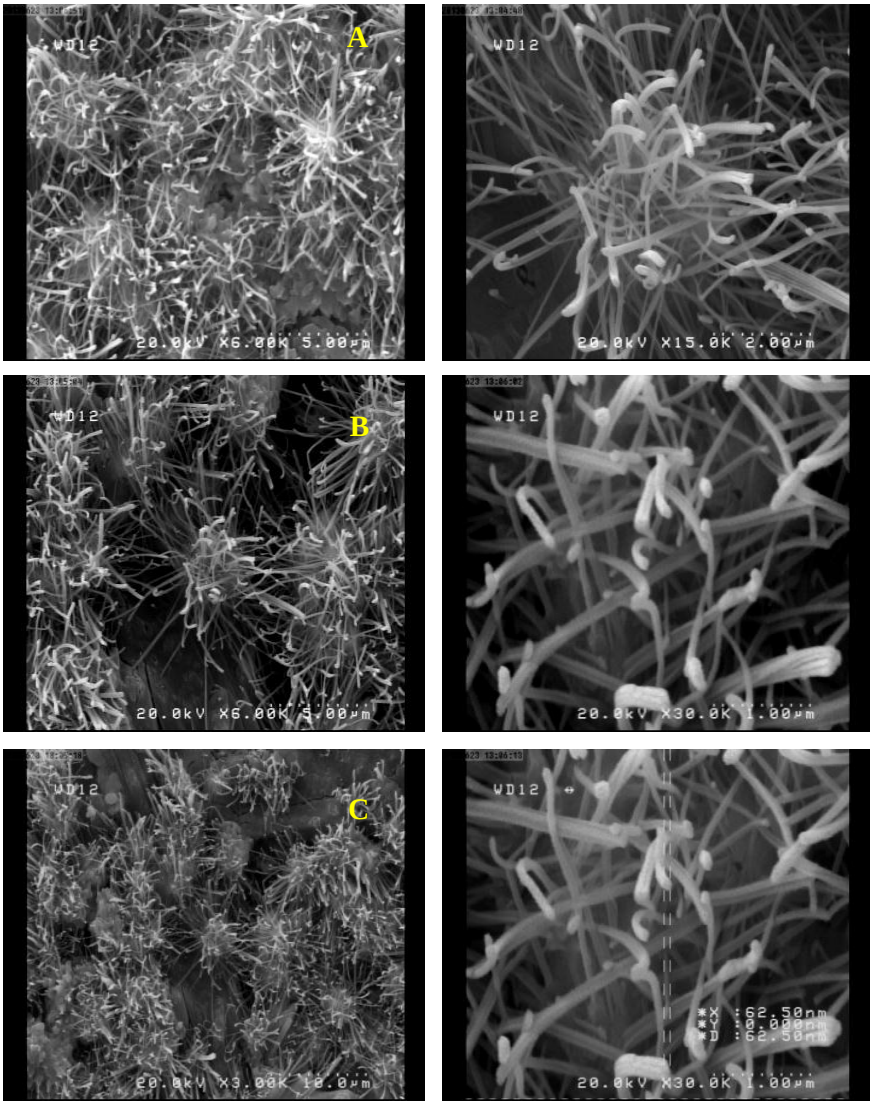

Figure (1) (a, b, c) SEM of silver NWs deposited on FTO coated quartz substrate.

The crystallinity of the produced material was characterized using X-ray diffraction (XRD). For Ag nanowire films depositing on FTO coated quartz substrate. Four peaks could be recognized in figure (2), the film is polycrystalline according to the ASTM standards card where (111), (200) and (220) Ag respectively could be recognized. This is related to the formation of silver NWs. All the peaks can be indexed to the face-centered cubic (**fcc**) phase of silver (JCPDS file No. 04-0783). No impurities can be identified from this pattern. The calculated lattice constant according to the (111) peak is 4.08 Å which is closely consistent with the standard value (4.086 Å).

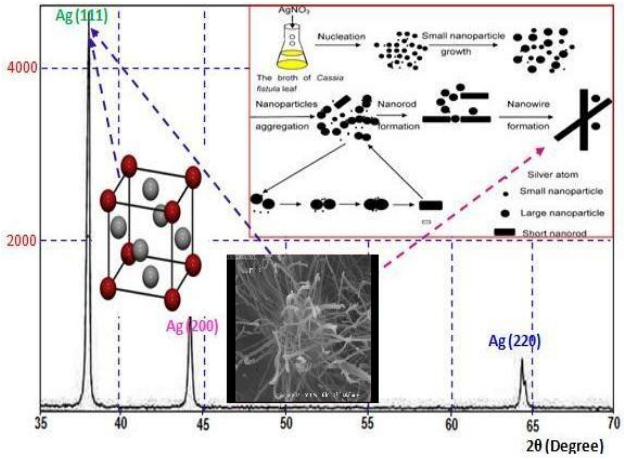

Figure (2) XRD pattern of silver NWs synthesized on FTO-coated quartz substrate.

Conclusions

Silver nanowire grow on FTO coated quartz substrate by using hydrothermal method .The morphology of the product is wire-like and nearly uniform in width (60 ± 10 nm), while the length is in a relatively broad range (from 0.2 to 4 μm) with an average at 2.5 μm. The calculated lattice constant according to the (111) peak is 4.08 Å which is closely consistent with the standard value (4.086 Å).

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