Synthesis and Characterization of Uniformly-Aligned MoO_3 Nanobelts

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***Abstract*—We have been synthesized MoO_3 nanobelts by thermal chemical vapor deposition. The growth products will be studied by field emission scanning electron microscope (FESEM), X-ray photoemission (XPS), Raman Spectroscopy, X-rays diffraction (XRD). SEM images showed the belts-like nanostructures. XPS and Raman shift showed the consisting of MoO_3 structure. XRD patterns indicated orthorhombic MoO_3 structures phase of planes (020), (110), (040), (021), (060) and (010).**

Keywords-MoO_3 nanobelts; thermal chemical vapor deposition; raman spectroscopy; XPS; XRD

I. INTRODUCTION

Molybdenum trioxide (MoO_3), a wide band gap n-type semiconductor is interested due to its structures crystal [1-3]. It was used in many applications such as hydrogen evolution [4], field emission [5], thin film transistor [6], capacitor [7] and gas sensor [8]. MoO_3 nanostructures, belts-like, wires-like, rods-like, nanodiscs, nanoflowers and nanosheets have been synthesized from many processes [2-5, 7-9]. MoO_3 nanowires with uniform in side can be formed on silicon substrates without using any catalyst by providing in two methods, thermal evaporation and oxidation [5]. The ordering MoO_3 nanosheets have been prepared via hydrothermal route using MoO_3 powder and hydroquinone as starting materials, for studying the conductivity mechanism of complex impedance and modulus formalism [8]. MoO_3 nanorods have been prepared using a simple ultrasonic method, for gas sensing high response to NO_2 [9]. Recently, the MoO_3 nanobelts can be synthesized by using ammonium molybdate tetrahydrate mixed with ethylene glycol as a starting solution, centrifugation and sintering of the precipitate, the result showed the α-MoO_3 nanobelts grew with a strongly preferred orientation [10]. In this paper, the MoO_3 nanobelts have been synthesized using MoS_2 powder as starting materials by chemical thermal vapor deposition.

II. EXPERIMENTAL PROCEDURE

The mixing of MoS_2 and S powder (SIGMA-ALDRICH) and SiO_2/Si substrate were put in the alumina boat. The alumina boat was placed on the middle of furnace quartz tube and heated at 700 ºC under mixing atmosphere of N_2 and O_2 gas with flow rate of 6 sccm for 1 h. The furnace quartz tube was cooled down to room temperature, nationally. Then, the alumina boat and substrate were taken out. We can observe the different color of formed products on substrate. The heated substrate was investigated by optical microscope (OM), field emission scanning electron microscope (FESEM), X-ray photoemission (XPS), Raman spectroscopy, atomic force microscope (AFM) and X-ray diffraction (XRD).

III. RESULTS AND DISSCUSIONS

After, the furnace tube was cooled down to room temperature, nationally. The formed products on substrate were characterization by OM, FESEM, XPS, Raman spectroscopy, AFM and XRD. The results show as follow.

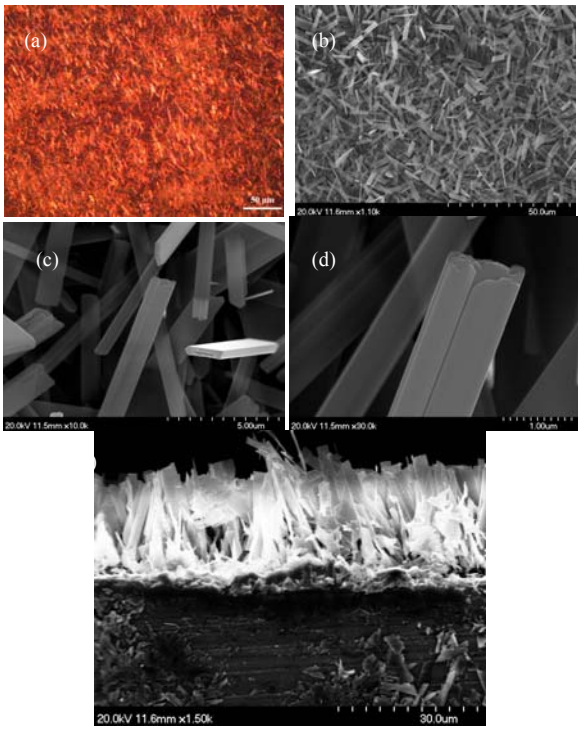

FIGURE I. OPTICAL MICROSCOPE (a), FESEM IMAGES OF MoO_3 NANOBELTS (b-d) AND CROSS-SECTION (e)

The figure 1 show the pictures of OM, FESEM and cross-section of substrate. We can see belts-like of formed products with length of more a few micrometers and width of around

200-500 nanometers. The synthesized materials grew from the bottom of substrate with height of about 21.7 micrometers. The XPS patterns showed the elements consisting of MoO_3 nanobelts.

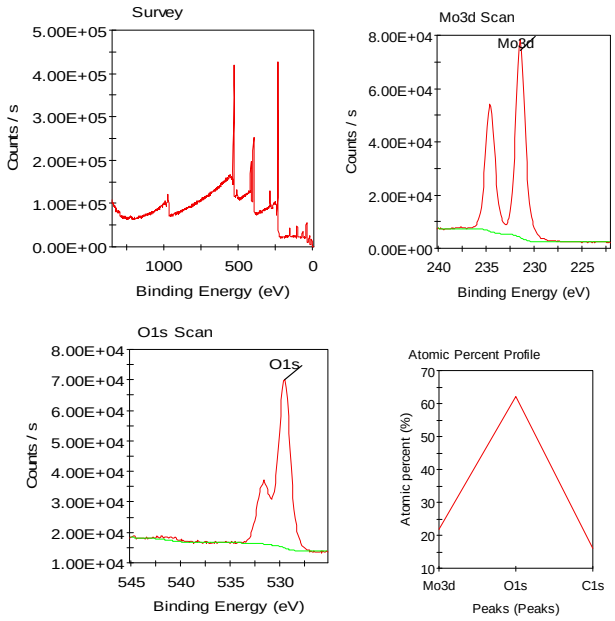

FIGURE II. XPS PATTERNS OF MoO_3 NANOBELTS

The XPS curves in Figure 2 revealed the elements consisting of prepared MoO_3 nanobelts with Mo and O atoms, the S atom no appear.

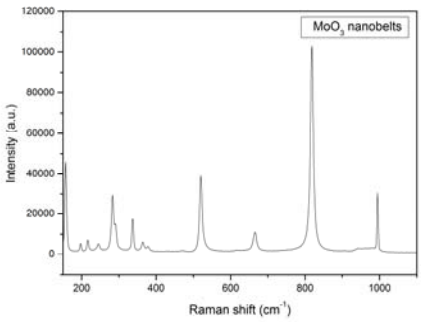

FIGURE III. RAMAN SHIFT OF MoO_3 NANOBELTS

The operating of Raman spectroscopy of MoO_3 nanobelts-like showed principal peaks of 994.2, 818.7, 666.4 and 284.5 cm^{-1}, respectively, and we can observed the interference peak of SiO_2 of SiO_2/Si substrate around 525 cm^{-1}.

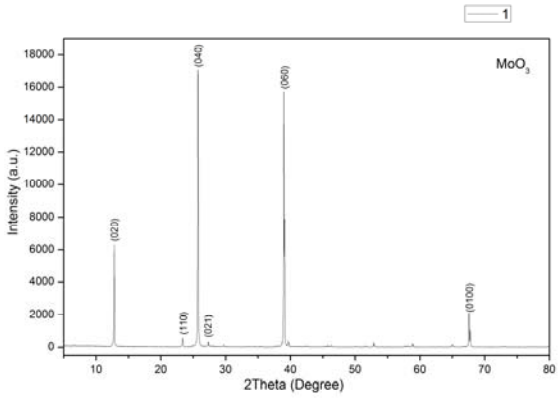

FIGURE IV. XRD PATTERNS OF MoO_3

Figure 4 showed XRD patterns of MoO_3 nanobelts with plane of (020), (110), (040), (021), (060) and (010). All of peaks correspond with MoO_3 (JCPDS reference card no. 05-0508) [11].

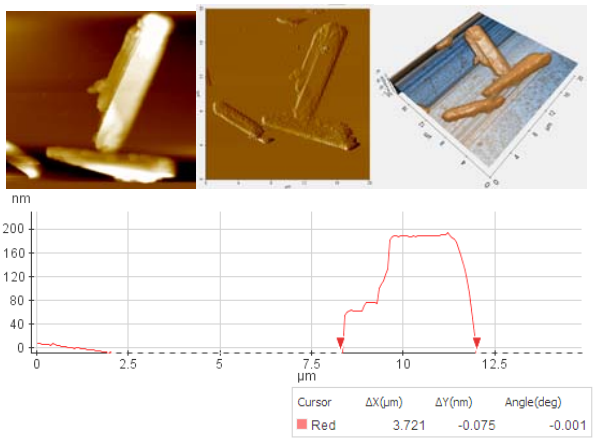

FIGURE V. AFM IMAGES OF SELECTED ANY MoO_3 NANOBELTS

The AFM images in FIGURE 5 show some selected MoO_3 nannobelts. This image reveals the morphology side of formed materials on substrate. The thickness of MoO_3 nanobelts are about 20-60 nanometer.

IV. CONCLUSION

In summary, The MoO_3 nanobelts can be synthesized by thermal chemical vapor deposition. The XRD, Raman shift and XPS were confirming that MoO_3 nanobelts as-synthesized, and OM, FE-SEM and AFM images showed the length, width and thickness of MoO_3 nanobelts with few micrometers, 200-500 and 20-60 nanometers, respectively.

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REFERENCES

[1] C-W. Chu, S-H Li, C-W. Chen, V. Shrotriya and Y. Yang, "High-performance organic thin-film transistors with metal oxide/metal", Appl. Phys. Lett. Vol. 87, pp193508(1-3), 2005.

[2] Ch.V.S. Reddy, E.H.Walker, C. Wen and S-I. Mho, "Hydrothermal synthesis of MoO_3 nanobelts utilizing poly(ethylene glycol)", J. Power Sources, Vol.183, pp330-333, 2008.

[3] G. Wei, W. Qin, D. Zhang, G. Wang, R. Kim, K. Zheng and L. Wang, "Synthesis and field emission of MoO_3 nanoflowers by a microwave hydrothermal route", J. Alloys and Comd., Vol. 481,pp 417-421, 2009.

[4] A. Phuruangrat, D.J. Hamb, S. Thongtem and J. S. Lee, "Electrochemical hydrogen evolution over MoO_3 nanowires produced by microwave-assisted hydrothermal reaction", Electrochem. Commun., Vol. 11, pp1740-1743, 2009.

[5] J. Zhou, S. Z. Deng, N. S. Xu, Jun Chen, and J. C. She, "Synthesis and field-emission properties of aligned MoO_3 nanowires", Appl. Phys. Lett. Vol. 83(13), pp2653-2655, 2003.

[6] C-W. Chu, S-H. Li, C-W. Chen, V. Shrotriya and Y. Yang, "High-performance organic thin-film transistors with metal oxide/metal bilayer electrode", Appl. Phys. Lett. Vol. 87, pp193508-193511, 2005.

[7] R. Liang, H. Cao and D. Qian, "MoO_3 nanowires as electrochemical pseudocapacitor materials", Chem. Commun., Vol. 47, pp10305–10307, 2011.

[8] R. Naouel, H. Dhaouadi, F. Touati and N. Gharbi1, "Synthesis and electrical properties of well-ordered layered-MoO_3 nanosheets", Nano-Micro Lett., Vol. 3(4), pp242-248, 2011.

[9] S. Bai, S. Chen, L. Chen, K. Zhang, R. Luo, D. Li and C.C. Liu, "Ultrasonic synthesis of MoO_3 nanorods and their gas sensing properties", Sens. Actuators, B, Vol. 174, pp51– 58, 2012.

[10] T.H. Chiang and H.C. Yeh, "A novel synthesis of α-MoO_3 and characterization", J. Alloys Comd., Vol. 585, pp 535–541, 2014.

[11] Y. Wang, Y. Zhu, Z. Xing and Y. Qian, "Hydrothermal synthesis of MoO_3 and the influence of later heat treatment on its electrochemical properties", Electrochem. Sci., Vol 8, pp 9851-9857, 2013.