Appl Phys A (2009) 97: 361–364
DOI 10.1007/s00339-009-5216-0

Applied Physics A
Materials Science & Processing

Growth of tin oxide nanotubes by aerial carbothermal evaporation

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Received: 6 August 2008 / Accepted: 30 March 2009 / Published online: 9 May 2009

Abstract One-dimensional nanostructures of tin oxide nanotubes were fabricated by carbothermal evaporation at 900°C in air. The synthesized film was grown on Au-coated (100) Si substrate. Heterogeneous catalysis by Au/Sn droplets assisted the formation of the tin oxide nanotubes of less than 40 nm diameter at Sn vapor pressures around 1.4×10^{-7} Pa. In order to reduce the nanotube diameter further, an increase in the Sn vapor pressure by changing the source materials' ratio seemed viable.

PACS 81.16.-c · 81.07.De · 81.16.Be · 81.07.Bc · 81.16.Pr

1 Introduction

Nanostructures of wide band-gap semiconductors have attracted great attention due to their potential applications in optoelectronic devices such as lasers, waveguides and field emitters [1–3]. In addition they are applied for gas sensing, energy storage/conversion, solar cells and transducers [4–6].

Tin oxide is a wide band-gap n-type semiconductor ($E_g = 3.6$ eV at 300 K) vastly used in the field of opto- and microelectronics including solar cells, transparent conducting electrodes, gas sensors and transistors [7–10]. Its one-dimensional nanostructures have been synthesized by different methods like hydrothermal treatment, carbothermal evaporation and direct oxidization techniques [11–13].

Pure and doped tin oxide nanostructures have both been grown on alternative substrates such as amorphous SiO_2, single-crystalline Al_2O_3, TiO_2 substrates [14], and sapphire [15] before. The electrical and optical properties of the one-dimensional SnO_2 nanostructures have been shown to be influenced by doping and changing of the diametric size [15].

In this work, tin oxide nanotubes were synthesized through an aerial carbothermal evaporation method. It was understood that tin oxide to carbon black ratio, as source materials, has a great effect on the diameter of the nanotubes produced. The synthesized nanostructures were characterized using a scanning electron microscope (SEM), transmission electron microscope (TEM) and X-ray diffraction (XRD) method.

2 Experimental procedure

Activated carbon (Aldrich Chemical Co., Ltd., Gillingham Dorset, England) and tin oxide (Hopkins & Williams, LTD, England) powders were used as source materials for growing tin oxide nanostructures via a carbothermal method. The powders were mixed in molar ratios of 1:2 of tin oxide to activated carbon (sample 1) and 1:4 of tin oxide to activated carbon (sample 2). The substrate was (100) silicon wafer (a) dipped in pure acetone and treated with ultrasound, (b) etched with 50 vol.% HF aqueous solution and (c) sputtered with Au for 30 seconds (Fisons, ARL Switzerland) at a vacuum pressure of 10^{-3} Torr and electric current

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