MORPHOLOGY CONTROL OF SELF-CATALYTIC INDIUM TIN OXIDE NANOWIRES BY OXYGEN

Kim Soo-Ho[1], *Roh Yong-Suk*[1], *Phan Van Cuong*[1], *Chang-Hwan Chang*[2], *Kim Do-Hyung*[1]
[1]*Department of Physics, Kyungpook National University, Nano Applied Physics Laboratory (NAPL), Daegu 702-701, Republic of Korea*
[1]*Research Institute of Industrial Science & Technology (RIST), Pohang, 790-600, Republic of Korea*

Kimdh@knu.ac.kr

Introduction

Control of nanostructures growth is of great importance for applications of future nanodevices based on bottom-up approach. Recently, a variety of oxide nanomaterials have been synthesized and studied for a number of their novel properties and applications [1,2]. Sn-doped In_2O_3, called indium-tin oxide (ITO), is one of most widely used transparent conducting oxides. There have been some reports on the synthesis and the structure characterization of ITO nanostructures [3,4]. The morphologies of ITO nanostructures can be influenced by multiple factors such as the growth temperature, the nature of substrate, growth time, growth ambient, and etc. However the effects of oxygen ambient on the control of morphologies of self-catalyzed ITO nanowires have not been discussed.

Experimental

The ITO nanowires were synthesized by a vapor transport and condensation method including a carbothermal reduction and a self-catalytic growth were used. First, Equal amounts of commercial ITO powder (10 wt% SnO_2 and 90 wt% In_2O_3, 99.99% purity) and graphite powder (99.99%) were mechanically pulverized together and transferred to an alumina boat. The alumina boat was placed in the center of the quartz tube furnace. Bare silicon substrates were inserted the tube positioned about 20 cm from the center of the boat under a constant flow of argon (Ar, 99.999%, 50 sccm) as the carrier. The oxygen (O_2, 99.999%, 2 sccm) was added as the reactive gas in order to for investigate the effect of oxygen gas on the nanowire growth. The pressure was maintained at 1.7 Torr. Then, the furnace heated to 900 ^{o}C and the corresponding substrate temperature is about 600 ^{o}C. The characterization of the ITO nanowires was analyzed using X-ray diffractometer (Philips, X PERT), scanning electron microscopy (SEM) (Hitachi, S-4300), and high-resolution transmission electron microscopy (HRTEM) (Philips, CM 200).

Results and discussion

Fig. 1(a) and (b) shows the SEM images of the as-grown ITO nanowires synthesized with and without the oxygen. With the exception of the oxygen, the other growth conditions were identical. The long pin-like nanowires (p-NWs) with the catalysts nanoparticles on the tip were grown in the absence of the oxygen, as shown in Fig 1(b). Elemental mapping of the Sn, In, and O content of the nanowire reveals that the spherical catalysts on the tip is metal Sn. Meanwhile the cone-like ITO nanowires (c-NWs) without the nanosized catalyst on the tip were grown in the presence of oxygen, as shown in Fig 1(a). The energy dispersive spectrum (EDS) reveals that the c-NWs consist mainly of In, Sn, and O showing a different atomic % ratio at the tip, body, and bottom parts. The XRD measurements show the significant metal Sn peak for the p-NWs without oxygen which was originated from the catalyst nanoparticles on the tip. The Sn metal peak of p-NW disappears during the heating at 150 ^{o}C. However, metal Sn in the XRD patterns of the c-NWs is not detectable, as shown in the inset of Fig 2. The Sn catalyst nanoparticles on the tip of the nanowire are effectively consumed to form the sharp nanowire during the growth in the presence of oxygen. However, the Sn nanoparticles can be remained on the tip in an oxygen deficient ambient without adding the oxygen. We will suggest more detailed mechanism for the sharpening process and additional morphology control of the ITO nanostructures.

References:

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Figures:

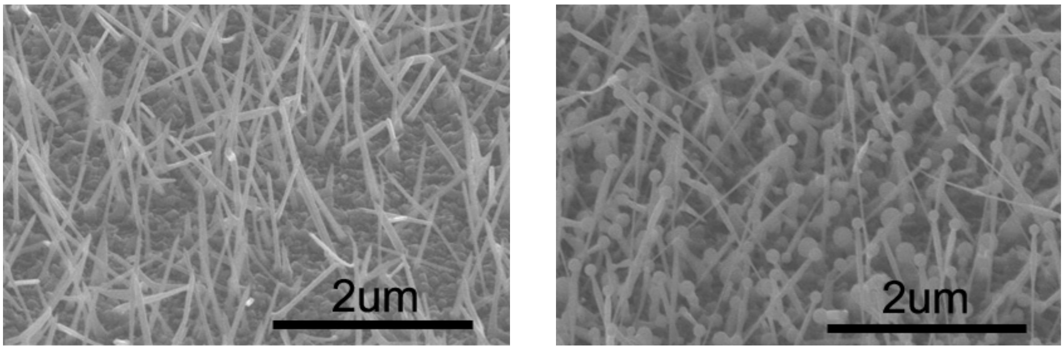

Figure 1. SEM images of ITO nanowires grown (a) with oxygen and (b) without oxygen.

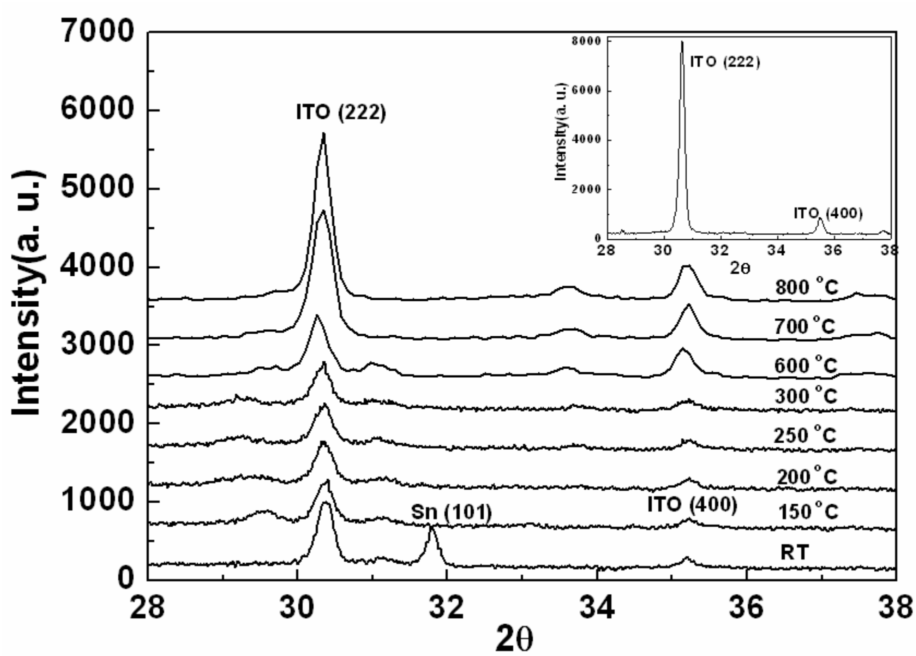

Figure 2. Temperature dependant XRD patterns of ITO nanowire grown without oxygen. (The inset shows XRD pattern measured at the room temperature for the nanowire grown without oxygen)