Journal of Physics and Chemistry of Solids 72 (2011) 904–907

Contents lists available at ScienceDirect

Journal of Physics and Chemistry of Solids

journal homepage: www.elsevier.com/locate/jpcs

A novel strategy to synthesize cobalt hydroxide and Co_3O_4 nanowires

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ARTICLE INFO

Article history:
Received 5 December 2010
Received in revised form
20 April 2011
Accepted 24 April 2011
Available online 14 May 2011

Keywords:
A. Nanostructures
B. Chemical synthesis
C. Electron microscopy
D. Crystal structure

ABSTRACT

Cobalt hydroxide ultra fine nanowires were prepared by a facile hydrothermal route using hydrogen peroxide. This method provides a simple, low cost, and large-scale route to produce β-cobalt hydroxide nanowires with an average diameter of 5 nm and a length of ca. 10 μm, which show a predominant well-crystalline hexagonal brucite-like phase. Their thermal decomposition produced highly uniform nanowires of cobalt oxide (Co_3O_4) under temperature 500 °C in the presence of oxygen gas. The produced cobalt oxide was characterized by X-ray diffraction, transmission electronic microscopy, and selected-area electron diffraction. The results indicated that cobalt oxide nanowires with an average diameter of 10 nm and a length of ca. 600 nm have been formed, which show a predominant well-crystalline cubic face-centered like phase.

1. Introduction

One-dimensional (1D) nanoscale materials such as nanotubes, nanobelts, nanorods, and nanowires have been prepared by different approaches, which can be classified into the following strategies [1,2]. First, the growth of 1D nanoscale materials is achieved in a hard template with well-confined structures, such as alumina, silica, block polymer, mica, and membranes [3,4]. Second, soft templates are used to produce 1D nanoscale materials [5,6]. Generally, in this process, surfactants are applied to stabilize the surface of nanonuclei and kinetically control the growth rates of various facets of nuclei. Third, the intrinsic structures are used to form 1D nanostructures [7,8]. Usually, the materials with hexagonal structure are favored to form 1D nanostructures under a suitable reaction condition. Fourth, vapor–liquid–solid (VLS) growth has been employed to prepare 1D nanostructures [9–11]. Recently, it was found that the low-temperature process based on one or more strategies described above is more promising to prepare 1D nanoscale materials.

Cobalt hydroxide nanostructure has attracted increasing attention recently because of its novel properties in technological applications [12–15]. In particular, cobalt hydroxide can be used to enhance electrochemical performance for enhancing the electrode conductivity and chargeability [16]. It is well known that cobalt hydroxide has two polymorphs: α- and β-$Co(OH)_2$. These two phases are all-layered and have the same hexagonal structures, except that the β form is isostructural with brucite-like compounds and consists of a hexagonal packing of hydroxy ions with Co (II) occupying alternate rows of octahedral sites [17]. α-$Co(OH)_2$, however, is isostructural with hydrotalcite-like compounds that consist of stacked $Co(OH)_{2-x}$ layers intercalated with various anions in the interlayer space to restore charge neutrality.

Spinel Co_3O_4 is an important p-type semiconductor due to its potential applications in ceramic pigments, solid-state sensors, energy storage as intercalation compounds, rotatable magnets, heterogeneous catalysts, and electrochromic devices [18–20]. Especially, it is very useful to prepare anisotropic antiferromagnetic nanostructures for studying the magnetic properties as a function of geometric structure [21]. Increasing interest has been generated with antiferromagnetic nanoparticles since the discovery of their potentials for quantum tunneling [22] and their applications in spin-valve systems [23]. Synthesis of cobalt oxide nanoparticles have been obtained by different methods as solvothermal, mechanochemical, reduction–oxidation, sol–gel, and polymer combustion, generating different morphologies like nanotubes, nanorods, nanocubes, and spherical particles [24–26]. Here, we employed a new approach to synthesize ultra fine cobalt hydroxide nanowires and their decomposition to Co_3O_4 nanowires. The structure and morphology of cobalt oxide nanowires were also investigated.

2. Experimental work

For the synthesis of cobalt hydroxide nanowires, 1 g cobalt powder (10 μm, particle size) and 3 ml of aqueous ammonia "surfactant" were dissolved in 25 ml hydrogen peroxide and stirred for 30 min. This solution was transferred into 80 mL

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doi:10.1016/j.jpcs.2011.04.014