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Short communication

Large-scale fast synthesis of single-crystalline alpha-alumina nanotubes

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Abstract

Large-scale single-crystalline α-Al_2O_3 nanotubes were synthesized by fast evaporation of pure Al powders using induction heating. The morphology and structure of the nanotubes were investigated by field emission scanning electron microscopy and transmission electron microscopy. The nanotubes exhibit a broad diameter-scale from about 20 nm to 150 nm and length up to more than 10 μm. The possible formation mechanism of the nanotubes was discussed. Phase transformation accompanied void generation might result in the α-Al_2O_3 tubular structure.

Keywords: Alumina; Fast synthesis; Nanotube; Phase transformation

1. Introduction

One-dimensional (1D) metal and transition metal oxides have drawn considerable attention due to their excellent physical properties as well as their potential applications [1–5]. Currently, 1D-nanostructured Al_2O_3, such as nanowires, nanorods and nonotubes, are of great interest in both academia and industry owing to its low density, high strength and toughness and high dielectric constant, which have been successfully synthesized thorough chemical etching, laser treatment, electrospinning technique and thermal oxidation in recent years [6–9]. Among 1D Al_2O_3 nanostructures, nanotubes are particularly attractive because it provides access to different contact regions, inner and outer surfaces as well as both ends. For non-layered materials, the formation mechanism of most of tubular structures can be regarded as a "template method" though the used templates and the routes are different [10]. The synthesis of Al_2O_3 nanotubes is no exception. Satishikumar et al. [11] prepared Al_2O_3 nanotubes using carbon nanotubes as template and aluminum isopropoxide (AIP) as precursor. Pu et al. [12] obtained individual Al_2O_3 nanotubes by etching porous alumina membranes which acted as the template. Wakihara et al. [13] synthesized Al_2O_3 nanotubes from polymer composite materials. Furfuryl alcohol was the actual template, and volume loss resulting from a phase transformation eventually resulted in the tubular structure. Herein, we report a facile and fast method for large-scale synthesis of α-Al_2O_3 nanotubes by direct evaporation of pure Al powders using induction heating. The formation of tubular structure possibly involved in the phase transformation from metastable Al_2O_3 to stable α-Al_2O_3.

2. Experimental

Pure Al powders with diameter of about 30 μm and graphite powders with diameter of about 20 μm were mixed in molar ratio of 1:1 as the starting materials. Fig. 1 shows the schematic diagram of the reactor setup for the growth of Al_2O_3 nanotubes. A high frequency induction system (60 kHz) was used for heating the mixed powders. A piece of graphite paper about 2 mm thick was used for induction heater. The mixed powders were spread on the graphite paper. The graphite paper with the mixed powders was placed below the copper inductor. The distance between the graphite paper and the inductor was about 20 mm. The applied power in this experiment was 45 kW. After induction heating for 3 min, the mixed powders were cooled down to room temperature. High

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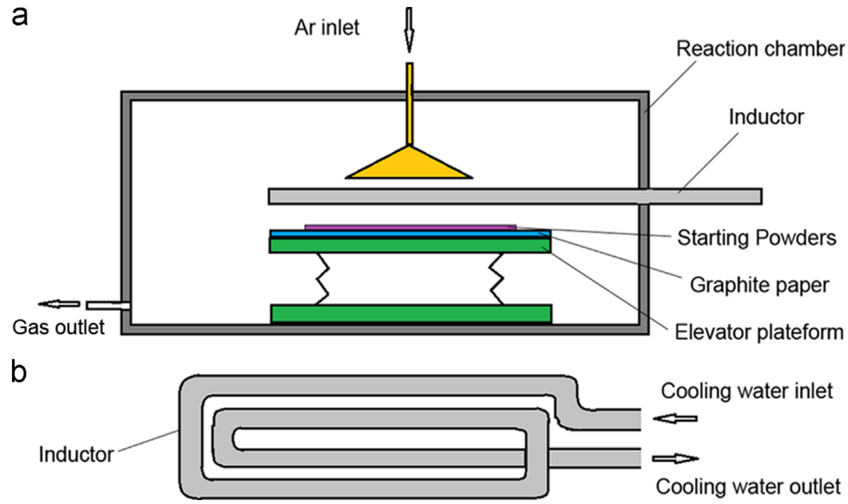

Fig. 1. Schematic diagram of the reactor setup for synthesis of alumina nanotubes.

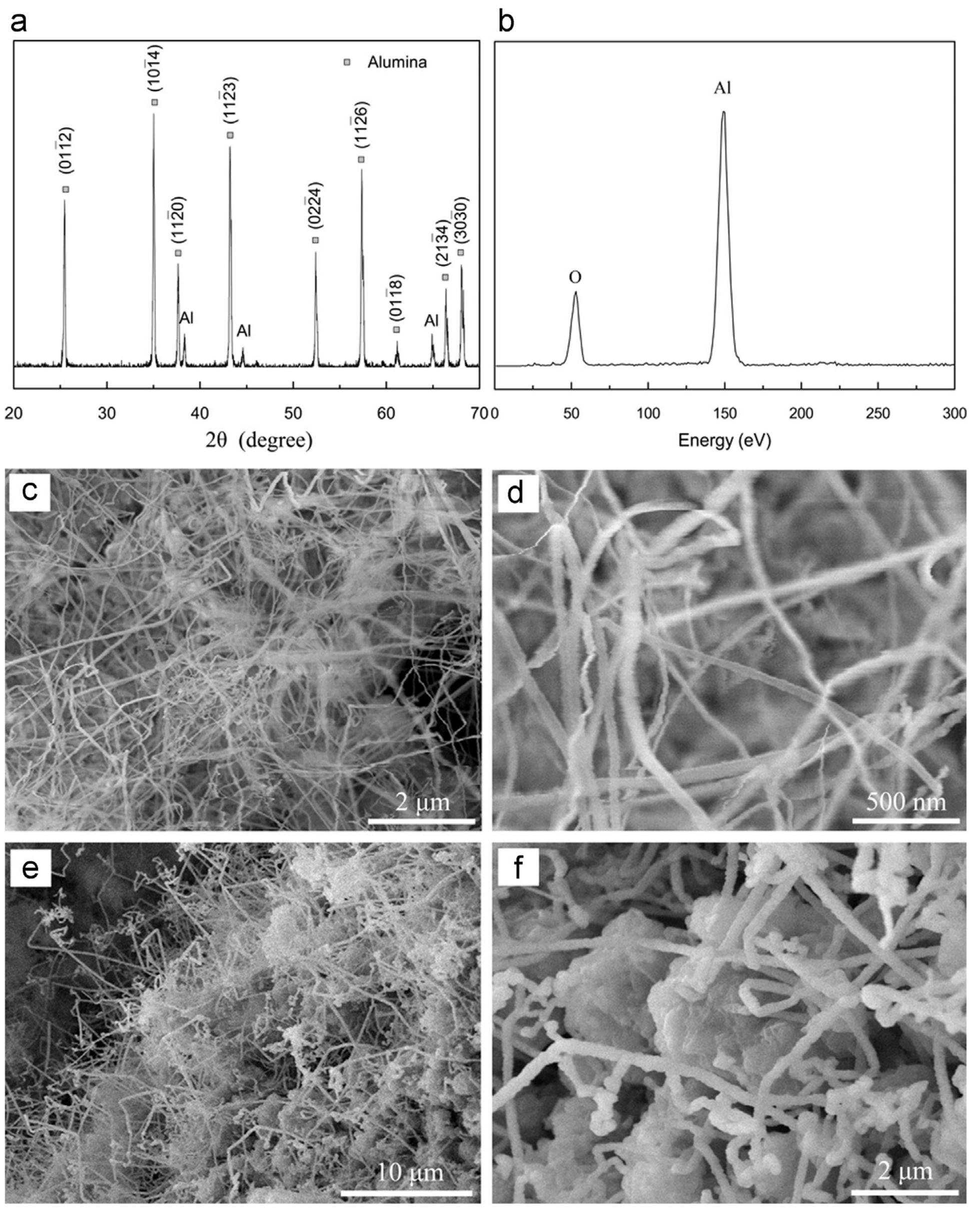

Fig. 2. XRD, EDS and SEM results of the product. (a) XRD pattern; (b) EDS pattern; (c) morphology of alumina nanowires; (d) magnification of (c); (e) another morphology of alumina nanowires; (f) magnification of (e).