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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　SAW MIN JIA

学 位 論 文 題 名

Anisotropic Growth of Metal Rods and Wires without Organic Capping Agents for Transparent Conducting Materials

(有機キャッピング剤を用いない金属ロッド・ワイヤの異方性成長および透明導電性材料としての応用)

Metallic micro- and nano- particles are highly interesting materials in the many fields especially for electronic devices. In a typical optoelectronic device structure, bottom electrode is often transparent conducting electrode while top electrode is normally an opaque metal thin film. The device performance can be enhanced by integrating a transparent conducting material (TCM) as the top electrode. Among the TCMs available, rod and wire-shaped metallic particles are particularly attractive since they provide high electrical conductivity, transparency, and flexibility. However, the syntheses of these morphologies often involve in complex system which require organic capping agents as shape-directing agents to promote the anisotropic growth of the particles. The presence of capping agents on the surface of the particles induces the challenges during the fabrication of electrodes as tedious post-process is required to remove the capping agents to improve the overall electrical conductivity of the electrodes. Hence, the metallic particles in rod or wire-shaped in micro- and nano- regime without organic capping agents are attractive. By using the metallic rods or wires which do not have any organic capping agents on the surface, the post-processing can be eliminated during the fabrication of electrodes. This thesis focuses on the anisotropic growth of the metallic particles into rod and wire-shaped without the need of organic capping agents and the application of such particles as top electrodes in optoelectronic device. The above research background and the objectives are introduced in chapter 1.

Chapter 2 presents the anisotropic growth of silver (Ag) nanowires without the organic capping agents. Among the metallic particles available, Ag is widely used as electrodes as it has highest electrical conductivity and highly stable against oxidation. The Ag nanowires were synthesized in ethylene glycol by a modified polyol method. Fe^{3+}/Fe^{2+} ions and Cl^{-}/O_2 pairs in the reaction system controlled the kinetic growth of Ag which led to the formation of nanowires. The effect of concentrations of Fe^{3+} ions on the morphologies of Ag was investigated. With different concentrations of Fe^{3+} ions, Ag nanowires with different aspect ratio were obtained. The electrical and optical properties of Ag nanowires was examined and found to be suitable for using as TCMs.

In chapter 3, the Ag nanowires which were synthesized without organic capping agents as shown in chapter 2, were applied as top electrode in a photodiode for the first time. The photodiode had an inverted structure with thermal deposited CBP/MoO_3 as active layers. The Ag nanowires were deposited by drop-casting on top of the active layers. The photodiode using Ag nanowires as top electrodes showed the highest responsivity at 340 nm and good switching behaviors. The demonstration on using Ag nanowires as top electrode in a photodiode showed the promising potential of such Ag nanowires to be used as top electrodes in full inverted structure optoelectronic devices in the future.

Chapter 4 presents new insights on the anisotropic growth of Cu rods without organic capping agents. Cu is a promising alternative material for Ag because Cu has good electrical conductivity and low electromigration, besides being cheap, abundant, and non-toxic. The Cu rods were synthesized in ethylene glycol by a chemical reduction method. The Cl^- ions in the reaction system had preferential adsorption on certain facets of Cu, leading to formation of rods. With different concentrations of Cl^- ions, the number of Cu atoms forming Cu rods, the preferential growth, the aspect ratio, and the particle number percentage of the rods varied. This chapter provided insight on the role of Cl^- ions in controlling the anisotropic growth of Cu rods without organic capping agents.

The fifth chapter covers the general conclusions of this research which include the application and new understanding on the anisotropic growth of metallic rods and wires at nano and micro scales without organic capping agents. The findings are significant to control the morphologies of metallic particles and to further widen their application in various fields.