The Field-Emission Characteristics of Aluminum-Doped and Silver Doped Zinc Oxide Nanorods

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ABSTRACT

In this study, aluminum-doped zinc oxide (ZnO) and silver-doped zinc oxide nanorods were grown by a hydrothermal method and the effect of varying the doping concentration on the field emission characteristics of the synthesized ZnO nanorods were studied. The growth procedure of ZnO nanorods is first spin-coating a seeding layer on silicon substrates, followed by the growth in the mixed solution of zinc nitrate hexahydrate (Zn(NO3)2 · 6H2O), hexamethylenetetramine (C6H12N4), and aluminum nitrate (Al(NO3)3 · 9H2O) or silver nitrate (AgNO3) at 90oC for 2 hours. The ratio of volume concentration of zinc nitrate hexahydrate to hexamethylenetetramine is 1:1. The purpose of aluminum nitrate and silver nitrate was to supply dopant atoms and the volume concentration was varied from 0.2% to 4% (i.e. 0.0000M to 0.0008M). Field-emission scanning electron microscopy (FE-SEM), field-emission tunneling electron spectroscopy (FE-TEM), energy dispersive spectrometer (EDS), X-ray diffraction (XRD) were used to investigate the surface morphology, chemical compositions, and microstructure of aluminum-doped ZnO and silver-doped ZnO nanorods, the electrical properties were determined by Hall effect measurement, and the field emission characteristics of ZnO nanorods were measured in high vacuum. As found by EDS results, dopant atoms such as aluminum (Al) or silver (Ag) have been successfully incorporated into the crystalline structure of ZnO nanorods, and the conductivity, the concentration and mobility of majority carrier of ZnO nanorods have been modified accordingly. As can be seen in SEM results, the surface morphology of ZnO nanorods can be affected by impurity doping. It is found from XRD and FE-TEM results that the ZnO nanorods are of hexagonal wurtzite structure with [0001] as the most preferential direction of growth. It is also found that the Al-doped ZnO nanorods grown with 2% aluminum nitrate have the largest field emission current 127.78 (μ A/cm2); while silver doped ZnO nanorods of field emission maximum is 77.5 (μ A/cm2). In this study, it is demonstrated that the field emission characteristics of the ZnO nanorods can be effectively enhanced by doping impurities.

Keywords : zinc oxide (ZnO)、doping、field emission

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