Polarity Determination of Polarity-Controlled ZnO Films Using Photoresponse Characteristics

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We report on the use of the photoresponse characteristics of polarity-controlled ZnO films for determining ZnO polarity. ZnO films were grown on CrN and Cr2O3 buffer layers in order to produce Zn- and O-polar films, respectively, and Ti/Au metal contacts were formed. All samples showed Ohmic behavior, but the Zn-polar ZnO film showed lower contact resistance than the O-polar ZnO film. The O-polar ZnO film showed higher photocurrent and longer decay time than the Zn-polar film by photoresponse measurement. These phenomena can be explained by the expansion of the depletion layer into the bulk ZnO surface. Compared with current methods, this method of determination of the polarity of ZnO films through the measurement of photoresponse characteristics is very easy and simple to implement.

Key words: ZnO, polarity determination, photocurrent

INTRODUCTION

Zinc oxide (ZnO) has a wide bandgap of 3.37 eV at room temperature,1 indicating that it is sensitive to ultraviolet (UV) wavelengths. Additionally, ZnO is an attractive photonic material for applications such as light-emitting diodes, solar cells, and UV photodetectors due to its large exciton binding energy of 60 meV.2,3 ZnO has a stable wurtzite crystal structure that produces crystal polarity along the growth direction (c axis) of a c-sapphire substrate, resulting in either (0001) Zn-polar or (000-1) O-polar ZnO. The structural, chemical, optical, and electrical material properties of ZnO can be affected by the crystal polarity.4,5 There has been a great deal of research conducted regarding the control and determination of ZnO polarity through the use of different interfacial layers, and significant results have been achieved.6–9 Methods for polarity determination of wurtzite compound semiconductors are categorized by the operation principles and control methods of the crystal polarity, as reviewed previously.10 However, current methods to determine polarity are very complicated and expensive. Therefore, the development of easy and simple methods to determine polarity without ambiguity is required. In addition, further characterization of the photoresponse of ZnO materials is needed to allow use of ZnO materials in UV photodetectors. Recently, Yamaguchi et al.11 reported that the two polar surfaces of bulk ZnO crystal showed different photoconductivity behaviors. Although there are many reports regarding the photoresponse characteristics of ZnO films and nanostructures, including nanowires and nanotubes, in the UV region, there have been few reports regarding thin films with different polarities.3,12,13 In addition, though the material properties of ZnO depend heavily on polarity, there has been little research regarding the photoresponse dependence of ZnO.11

In this study, we report the photoresponse behavior of ZnO films as an easy method to determine polarity. X-Ray diffraction (XRD) and Hall measurements were conducted to obtain the structural and electrical material properties, respectively, of polarity-controlled ZnO films. The surface morphologies were confirmed by atomic force microscopy (AFM). Ti/Au metals were used as a contact electrode to investigate the photoresponse and Ohmic characteristics.