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Cathodic arc deposition with activated anode (CADAA) for preparation of in situ doped thin solid films

Hirofumi Takikawa*, Keisaku Kimura, Ryuichi Miyano, Tateki Sakakibara

Department of Electrical and Electronic Engineering, Toyohashi University of Technology, Tempaku-cho, Toyohashi, Aichi 441-8580, Japan

Abstract

Cathodic arc deposition with an activated anode was developed for preparing doped thin solid films. The activated anode was a water-cooled crucible, and the material in it was evaporated and ionized by passing a partial arc current through the crucible. As an example, aluminum-doped zinc oxide (ZnO:Al) was synthesized by a Zn cathodic arc in an oxygen (O_2) gas flow at 1.0 Pa. Al powder was used as a dopant precursor and placed in the crucible. The anodic plume plasma appears on the crucible anode, which is composed of cathode material of Zn and anode material of Al as well as a reactive gas of O_2. Energy dispersive X-ray analysis revealed that the prepared-film contained Zn, Al and O. The ZnO:Al film on the glass substrate was transparent with a very strong X-ray diffraction peak of ZnO.

Keywords: Cathodic arc deposition; Activated anode; ZnO film; Al doping; Film properties

1. Introduction

Transparent conductive films have been widely used as transparent electrodes in many industrial optoelectronic devices such as photovoltaic cells, liquid-crystal displays, touch-screen displays, and window heaters [1,2]. These films can be prepared using pure metal oxides such as tin oxide (SnO_2), indium oxide (In_2O_3), zinc oxide (ZnO), and cadmium stannates (Cd_2SnO_4, $CdSnO_3$). However, in order to achieve the low resistivity and high stability, doped oxides, e.g., tin-doped indium oxide (In_2O_3:Sn, ITO; indium tin oxide), aluminum-doped zinc oxide (ZnO:Al), antimony-doped tin oxide (SnO_2:Sb) and cadmium-doped tin oxide (SnO_2:Cd), etc. are usually employed.

Transparent films have been prepared by a variety of deposition techniques such as spray pyrolysis, chemical vapor deposition (CVD), evaporations, and sputtering. Cathodic vacuum arc deposition is a new way to prepare such films. Ben-Shalom et al. have prepared SnO_2 by filtered vacuum arc deposition [2], and the present authors have prepared ZnO by shielded and non-shielded vacuum arc depositions [3–5]. However, there is no report with regard to in situ doping technique simultaneous with film preparation using cathodic arc deposition. In the present work, cathodic arc deposition with an activated anode (CADAA) is developed for the preparation of multi-element thin solid films such as ZnO:Al.

*Corresponding author. Tel.: +81-532-44-6727; fax: +81-532-44-6727.

E-mail address: takikawa@eee.tut.ac.jp (H. Takikawa).

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