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ZnO Film Fabrication by Reactive Shielded Vacuum Arc Deposition

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Zinc oxide (ZnO) thin films were prepared on borosilicate glass substrates by reactive shielded cathodic arc deposition. The macrodroplet shield plate was placed 100 mm from the cathode in order to prevent the macrodroplets from adhering to the film, and the substrate was placed 100 mm from the shield plate. The arc was operated at DC 30 A and the process pressure was varied from 0.1 to 5.0 Pa. No bias voltage was applied to the substrate. The substrate temperature was below 75°C. The arc voltage, erosion rate of the cathode, and film deposition rate were measured as process characteristics. The crystalline state, transmittance, refractive index, and electrical resistivity of the films were analyzed. The maximum deposition rate (40 nm/min) was obtained at 1.0 Pa. The films exhibited a hexagonal wurtzite polycrystalline structure and were highly oriented to the *c*-axis, perpendicular to the substrate. Well-crystallized and highly transparent films were obtained in the pressure range of 0.5 to 3.0 Pa. However, the lowest resistivity (10^{-3} Ω cm) was obtained at 0.1 Pa, and this resistivity increased with the process pressure. The refractive index at 600 nm varied from 1.8 to 1.9.
Keywords: zinc oxide film, reactive shielded cathodic arc deposition, process characteristics, film properties

1. INTRODUCTION

Zinc oxide (ZnO) exhibits outstanding potential properties, such as optical transparency in ultraviolet and visual regions, low electrical resistivity, good piezoelectric, photoelectric, and electrooptic properties, and a wide optical band gap (typically, 3.3 eV). Therefore, much attention has been paid to ZnO thin film and its application to surface acoustic wave (SAW) devices, ultrasonic transducer arrays, chemisorption gas sensors, mass-loading sensors, transparent electrodes used in solar cells, optical wave guides, and others [1, 2]. To date, ZnO thin film has been produced by a variety of techniques, such as spray pyrolysis [3-5], chemical bath deposition [6], chemical vapor deposition (CVD) [7-9], various sputtering techniques [2, 10-12], laser deposition [1], and cathodic arc deposition [13].

The cathodic vacuum arc deposition process is one of the ion plating methods and exhibits a high deposition rate, excellent adhesion, ease of system scale-up, and does not require a crucible. However, the major disadvantage of the process is the emission of macrodroplets from the cathode spot and their adhesion to the films under preparation. This problem can be overcome by employing the shielded method [14]. The authors have successfully prepared various metal-nitride and oxide thin films using a shielded cathodic vacuum arc [13, 15-17]. In the present study, ZnO films were prepared by this method as a function of process pressure. The process characteristics of arc voltage, erosion rate of cathode target, deposition rate, and substrate temperature were measured. The film properties of crystalline state, optical properties and electrical resistivity were investigated.

2. EXPERIMENTAL DETAILS

A schematic diagram of a reactive shielded vacuum arc deposition apparatus is shown in Fig. 1. A Zn cathode of 64 mm diameter was placed in a cylindrical chamber (SUS304, 600 mm in length, 400 mm in diameter), which was an anode and grounded. The substrate holder table (SUS304, 150 mm in diameter) was placed 200 mm away from the cathode surface, and the shield plate (SUS304, 64 mm in diameter, 1 mm thick)

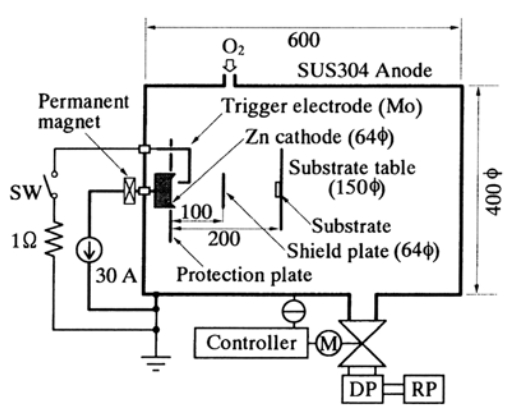

Fig. 1. Reactive shielded cathodic vacuum arc deposition apparatus (M: motor, DP: diffusion pump, RP: rotary pump).