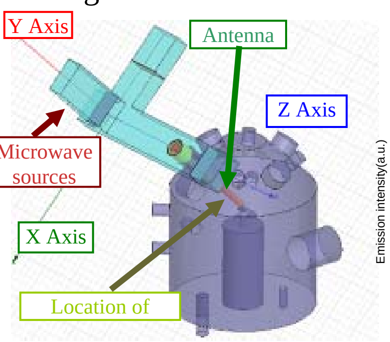
ZnO Films Fabricated by Microwave Plasma Jet Sintering System

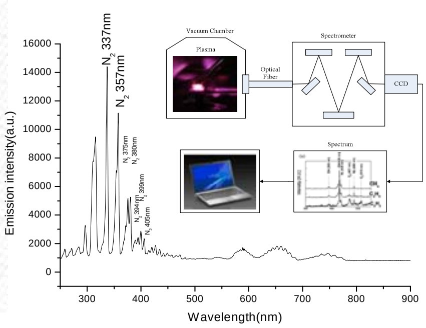
C. H. Su, C. M. Huang

Graduate Institute of Mechanical and Electrical Engineering ,National Taipei University of Technology, 10608 Taipei, Taiwan

such@ntut.edu.tw

Plasma is broadly applied to various areas such as thin films growth in manufacturing semiconductor integrated circuits and etching of such circuits [1].This study aims at optical response, ranged from ultraviolet (UV) to visible (Vis) light, of zinc oxide (ZnO) films heated by microwaves with different powers, adjusted by various positions of E-H tuner, using microwave plasma jet sintering system (MPJSS.) The distribution of electrical field (E-field) near specimen surface and antenna tip of MJPJSS is calculated in advance using Ansoft HFSS simulation software, a three-dimensional electrical field simulation program, in order to precisely control applied microwave during plasma processing. Ball-milled ZnO powders, with average size of 255 nm, were dispersed in methanol solution and then spread on quartz substrates. The as-obtained ZnO/quartz was heated in MPJSS to form ZnO films on quartz. Field emission scanning electron microscopy (FE-SEM) and UV-Vis light spectrometer were used to analyze microstructures and optical response of as-made ZnO films. Three-dimensional model of MPJSS was first built up using HFSS software, as shown in Fig. 1.The optical emission spectrum (OES) of plasma can be treated as process fingerprint and become control parameter for process monitoring since various processes and the corresponding concentrations of their precursors will cause unique OES of their own [2]. The technique of OES belongs to a non-contact remote measurement and is very suitable for plasma diagnosis. Species in plasma can be identified through comparison of measured OES with referenced database. The integration time, or the exposure time, of measurement should be adjusted to obtain enough intensities of spectrum in the shortest period for catching instantaneous variations of plasma. This study uses OES as process monitoring tool and the integration time for N_2 plasma is 100 ms, as shown in Fig. 2. As shown in Fig. 3, transmission percentages of films decrease with increasing microwave power. It shows that as-heated ZnO films will absorb UV light. The maximum absorption peak locates at around 375 nm. However, microwave powers of 1.2 kw and 1.5 kw do not show enhanced UV-absorption because the corresponding reflected powers are both more than 20% and the microwave energies are not fully input to antenna tip for heating.





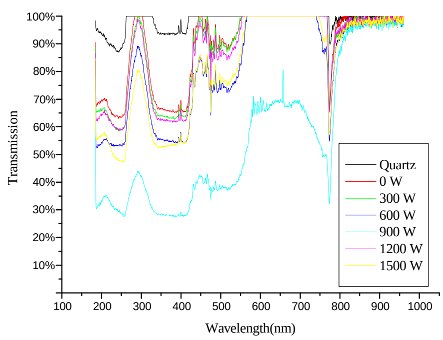


Fig. 1 Model of MPJSS for HFSS Fig. 2 OES of N_2 plasma Fig. 3 UV-Vis transmission spectrum

[1] C. Zhang, Journal of the European Ceramic Society **28** (13), (2008) 2529.

[2] Michael D. Whitfield, Microwave plasma characteristics during bias-enhanced nucleation of diamond: An optical emission spectroscopic study, J. Appl. Phys. **80** (7), (1996)