Development of Yttrium Oxide Deposition Process using Microwave Excited Atmospheric Pressure Plasma Jet

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1. Introduction: Yttrium oxide (Y_2O_3) is one of the most promising materials for plasma resistant materials inside the chamber because of its high chemical stability up to 2300 ºC as well as its high thermal stability compared to the conventional alumina and other ceramic materials. At a higher integration density, a higher plasma density and extremely low particle generation are required in the semiconductor chip fabrication process [1-3].

In this study, we aim to develop a Y_2O_3 film formation method and investigate its applicability using a Microwave-excited Atmospheric Pressure Plasma Jet (MW-APPJ). Ar gas was introduced into a Y_2O_3-containing organic precursor solution in order to carry precursor to plasma generated region.

2. Experimental: Experimental apparatus is shown in Fig. 1. Microwaves of 2.45 GHz as applied to a plasma jet reactor via an isolator, an E-H tuner, and a coaxial waveguide transducer. Microwaves was modulated at a pulse frequency of 10 kHz and a duty factor of 50%. The MW-APPJ reactor consists of a microwave resonance part with a cylindrical container, a gas inlet port, and a quartz nozzle. The quartz tube nozzle was placed at the lower end of the central axis of the reactor. The microwave was applied to the quartz tube nozzle to generate MW-APPJ. Ar gas was used as main operating gas at a flow rate of 0.5 slm. Ar carrier gas was introduced into a solvent tank at a flow rate of 0.1 slm. Ultra pure water and an organic Y_2O_3 precursor solution were prepared individually in the solvent tank to investigate vapor introduction to the carrier gas. $Y(CH_3COO)_3 \cdot 4H_2O$ was used as a base material for Y_2O_3 precursor solution. A Photonic multichannel analyzer (PMA-12) was used to measure optical emission spectra from MW-APPJ. Measurement position was adjusted at 3 mm below the quartz nozzle using a quartz lens. A quartz glass substrate was placed at 5 mm below the quartz nozzle edge to deposit a thin film.

3. Results and discussions: Optical emission spectra from MW-APPJ with Y_2O_3 bubble were shown in Fig. 2. Ar I spectra were appeared in 690 – 850 nm. Emission spectra of C_2 (Swan system, $A^3\Pi_g$–$X'^3\Pi_u$, Δv=0, 516.5 nm and Δv=-1, 563.6 nm), O I (777.1 nm) and H_α (656.3 nm) were observed clearly, suggesting dissociation of Y_2O_3 precursor solution. In addition, we have found that the optical emission intensity of not only atomic lines but also observed molecular band

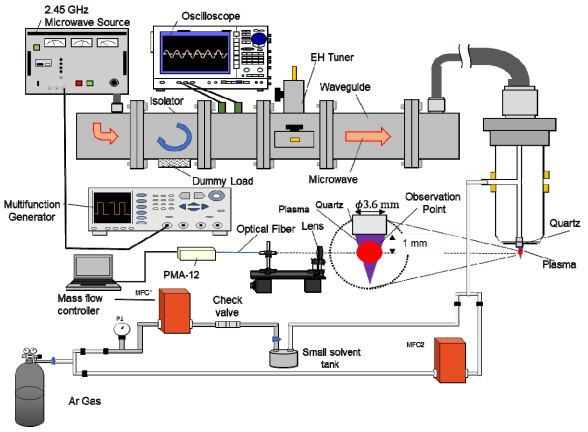

Fig. 1 MW-APPJ with bubbling system.

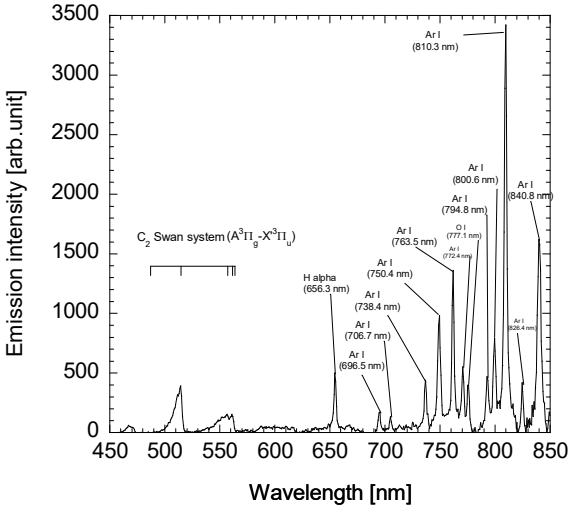

Fig. 2 Optical emission spectra of Ar MW-APPJ with Y_2O_3 precursor solution vapor.

spectra decreased as increasing the carrier gas flow rate, indicating reduction of the electron energy and electron density due to the higher collision rate between electrons and vapor molecules with higher density in the carrier gas.

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