EFFECT OF THE ALPHA–GAMMA MODE TRANSITION ON THE PLASMA-ENHANCED ATOMIC LAYER DEPOSITION WITH RF CAPACITIVE DISCHARGES

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Plasma-enhanced atomic layer deposition (PEALD) is a thin film deposition technique, where the surface growth is controlled by separated pulsing of vapor phase reactant and species generated by a plasma. Typical plasmas for PEALD are O_2, N_2, and H_2 that can be applied to deposition of oxide, nitride, and metal thin films. The plasma can be generated using several different configurations, of which inductive and capacitive discharges are the most common. In capacitively-coupled plasmas the discharge is generated by radio-frequency applied between parallel electrodes. These systems can be operated at a wide pressure range, but pressures on the order of 0.1 to 10 mbar are the most used in PEALD applications. In this pressure range the capacitive discharge can exist both in a low-current (α) and high-current (γ) mode. The modes differ in the dominant ionization process, sustained by either the bulk ionization (α) or the secondary electron emission from the surfaces (γ). The $\alpha - \gamma$ transition corresponds to the plasma sheath breakdown, which can be induced by increasing the power delivered to the plasma. This transition in the used PEALD configuration was observed both as a change in the optical emission spectrum of the plasma and as an increase in the DC-bias of the powered electrode (Fig.1). The effect of the plasma characteristics, such as the electron density and energy on the the PEALD process are investigated by depositing thin films under both modes, which are controlled by tuning the system matching network during the deposition. Characterization of the film properties provides information of the surface processes during the PEALD.

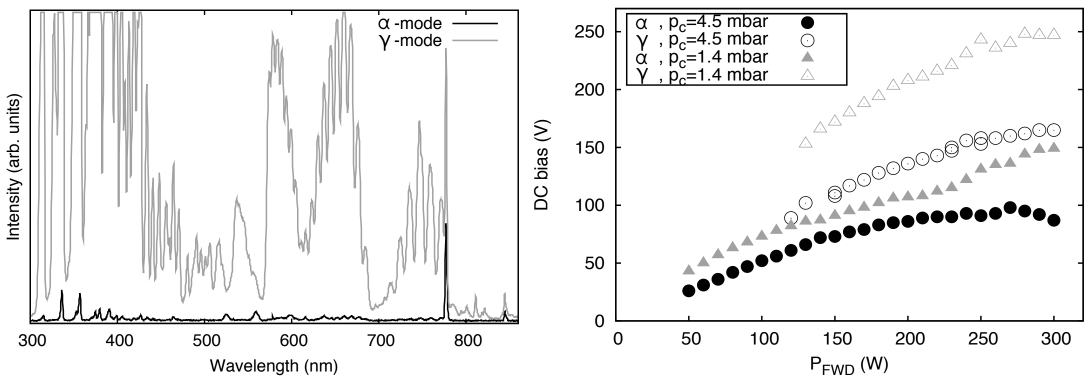

Figure 1: Left: An example of optical emission spectra of O_2/N_2 plasma at α- and γ-modes (P=150 W, p=4.5 mbar). Right: The plasma electrode bias voltage as a function of the delivered power.