Importance of Consideration of Thermal Diffusion Effects in a Non-isothermal Capacitively Coupled Plasma Reactor

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In the recent semiconductor industry, plasma enhanced chemical vapor deposition (PECVD) is often performed under non-isothermal reactor wall conditions. In the meantime, heavier reactive gases are diluted in lighter carrier gases for various PECVD cases, and their large mass (or size) discrepancies cause thermal diffusion with help of the temperature gradient inside of a reactor. Thermal diffusion induces a concentration of heavier, larger molecules in colder regions, whereas lighter, smaller molecules move towards the hotter regions. As a result, the deposition rate value and profile can be significantly modified by thermal diffusion. Since deposition rate uniformity of better than 1~5% is required in the recent process, an accurate numerical model often needs to involve thermal diffusion effects. Thus, referring the gas kinetic theory, we alter a mole fraction of a source gas, a gas velocity magnitude, and a susceptor temperature, to investigate the thermal diffusion effects on plasma density distributions. For the particular case of a PECVD example, we investigate SiH_4/He CCP discharges to deposit amorphous hydrogenated silicon (a-Si:H) films. It is found that the effect of the susceptor temperature on thermal diffusion is most important for finding the condition for the uniform deposition rate profile.

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