# Model Predictive Control of Electron Density for Ar/$SF_6$ Etching Plasma

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Maintaining reproducibility of plasma assisted processes have been a hot issue in semiconductor manufacturing. To keep the process plasma steady, there were many attempts to adopt real-time feed-back control methods to plasma sources. Because of its simplicity, proportional integral derivative (PID) controllers were usually adopted to plasma electron density controls. However, PID does not guarantee optimal control as it does not contain direct knowledge of the system and thus shows poor performance in some applications. In this study, we proposed model predictive controllers (MPC) as an alternative way to develop the real-time feed-back controller for electron density in capacitively coupled Ar/SF6 etching plasma. MPC determines control moves by estimating future steps with given dynamic model. We used First Order Plus Dead Time (FOPDT) model as it is well known that electron density of the plasma is proportional to the absorbed electric power. The dead time is determined by the specification of equipment as the energy relaxation time of electron is much shorter than the actuation of equipment. We trained the control model and tuned the optimizer of MPC with sensitivity tests; observing the variation of electron density as changing the incident electric power. It was experimentally shown that the MPC had better performance than PID had in set-point tracking tests and perturbation attenuation tests. Hence, we confirmed that the MPC is proper to process plasma systems as it considers the delay between plasma reaction and equipment actuation.

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