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学位（博士）論文要旨

(Doctoral thesis abstract)

論文提出者 (Ph.D. candidate)	工学府博士後期課程 機械システム工学 専攻 (major) 平成 29 年度入学 (Admission year) 学籍番号 17833702 氏名 田村 仁 (student ID No.) (Name)
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論文題目 (Title)	Study on microwave propagation and uniform plasma generation in an electron cyclotron etching reactor for semiconductor manufacturing
論文要旨 (2000 字程度) (Abstract(400 words)) ※欧文・和文どちらでもよい。但し、和文の場合は英訳を付すこと。 (in English or in Japanese) In the field of semiconductor manufacturing, plasma etcher utilizing electron cyclotron resonance has been developed over 30 years and used by major ULSI manufacturers since it has many advantages such as uniform plasma generation, controllability, and low wall damage. However, the mechanism of uniform plasma generation, which is essential to improve the ECR etcher, is not sufficiently understood. One of the reasons is complexity of the microwave distribution in the ECR reactor. It is well known that the microwaves propagate in the ECR plasma, and the wavelength becomes very short near resonance region. In this thesis, first we identified microwave analysis in the ECR plasma by comparing the calculated results with theoretical analysis and found that Trivelpiece-Gould wave (TG wave) whose field pattern was very complicated was observed, which showed that the simulation tool is valid and useful. Next, we developed a simulation tool for ECR plasma etcher by combining the validated microwave tool with plasma generation analysis and plasma diffusion analysis, and confirmed the accuracy of the tool by comparing the simulation results with experimental ones. By using the developed tool with considering plasma density distribution, we found a phenomenon that introduced microwave of right-hand polarized wave (R wave) does not enter high density region of $\omega_{pe}/\omega > 1$, where ω_{pe} is plasma angular frequency, and ω is angular frequency of the microwave. This phenomenon played an important role in uniform plasma generation. However, from the theoretical dispersion relation in unbounded space, R wave in principle can propagate in high density plasma of $\omega_{pe}/\omega > 1$ and does not have cutoff in the region of high static magnetic field of $\omega_{ce}/\omega > 1$. To solve the contradiction, theoretical analysis of plasma waveguide with outer vacuum layer was performed, and it was found that the reason of the phenomenon that the microwave does not enter high density plasma is the effect of the wall boundary. Moreover, it was demonstrated that, for the	

first time as far as we know, the phenomenon can be understood by the mode transformation from the introduced right-hand polarized wave (R wave) to extraordinary wave (X wave) and TG wave at around the region of $\omega_{pe}/\omega = 1$.