SUMMARY OF Ph.D. DISSERTATION

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Title

Optical diagnostics of functional separation and plasma-surface interaction in two frequency inductively coupled plasma

Abstract

Shrinkage and integration of LSI has been still progressed. Plasma process is one of the most important technologies in LSI fabrication. A quantitative control and optimization of the low temperature plasma is essential for the improvement of the production yield and performance of the next-generation LSI. In this paper, the specific plasma structure of two frequency Inductively Coupled Plasma (2f-ICP) in CF_4/Ar and Ar, widely used as high density plasma etcher at low pressure, are experimental investigated for the functional separation between generation of the ICP and the control of the ion energy, and the plasma-surface interaction by using optical diagnostics. The outline of this study is as follows.

In chapter 1, general plasma process for manufacturing LSI and its property are described. The background and the objective of the present study are shown.

In chapter 2, the apparatus and the procedures used in this study, i.e., the ICP reactor, optical emission spectroscopy (OES), laser absorption spectroscopy (LAS), and computerized tomography (CT) technique are described in detail.

In chapter 3, the spatial structure and transition mechanism of the CF_4(5%)/Ar and Ar ICP are observed by using CT-OES. The 3D images of the ICPs in E- and H-mode are observed and the transition between both modes are measured and discussed from the view points of stabilization of the ICP. The generation and loss, and the transport property are measured in the CF_4/Ar and Ar ICP by using CT-LAS for Ar metastables as an optical probe of the fluorocarbon radicals (CF_x) which play an important role in SiO_2/Si etching.

In chapter 4, measurements are made to investigate the spatiotemporal structure of the etch products, their derivatives and the etchants during SiO_2 (or Si)- etching in CF_4 (5%)/Ar in 2f-ICP by using CT-OES. As a result, their spatiotemporal behavior, and the correlation between the etch products and the etch rate of SiO_2 (or Si) are investigated and discussed. The functional separation between the plasma production and ion acceleration by the low frequency source are experimentally confirmed in the ICP for SiO_2 etching.

In chapter 5, the conclusion of this study is summarized.