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Formation of High Flux Parallel Neutral Beam using a Three Grid System of Ion Beam during Low Angle Forward Reflection of Ions

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Abstract. The energy and the flux of the ion gun with a three-grid system was compared with those of the ion gun with a two-grid system and the characteristics of the neutral beam sources composed of the ion guns with different grid systems and a reflector for the low angle reflection of the ions were investigated. By using the three-grid system instead of the two-grid system and by applying higher negative voltage to the 2nd grid, a higher ion flux without changing the ion energy could be obtained for the ion gun of the neutral beam source. The three-grid ion gun system generated higher neutral beam fluxes compared to the two-grid ion gun system. This result was confirmed by measuring the etch rates of Si and GaAs with Ar and fluorine neutral beam. Also, using the neutral beam source with the three-grid ion gun, 35nm-width Si patterns could be etched vertically by CF_4 gas indicating the formation of a parallel neutral beam.

Introduction

To avoid the charge-related damage, several low-damage processes have been proposed [1] and one of the techniques to avoid the problem is to use neutral beam. [2-4] In our previous study, a neutral beam etcher called “low angle forward-reflected neutral beam etching apparatus” has been developed. During the reflection on the reflector of the ion beam extracted from the ion gun through the grid system, the extracted ions are scattered, therefore, some of the energy and flux of the ion beam are lost during the neutralization by reflection at the reflector. To have a higher processing rate, a higher neutral beam flux is required.

One of the methods in obtaining higher neutral beam flux is to optimize the grid system of the ion gun for the neutral beam source. In fact, for the grid system of the general ion gun, various parameters of the grid structure including number of grids and the thickness, distance, and hole size of the grids had been studied to improve ion extraction characteristics such as beam flux and divergency of the ions. [5-6] In this study, as the grid systems for the netural beam formation, two different grid systems composed of two grids and three grids were fabricated and the effect of grid system on the flux and energy of the ion beam and on the resulting flux of neutral beam was investigated. Also, the directionality of the neutral beam formed by the three-grid system was investigated by etching 35 nm scale Si and by observing the etch profiles.

Experimental Procedure

The neutral-beam etching source used in this experiment was composed of an rf ion gun and a planar reflector. Fig.1 shows the schematic diagrams of the low-angle forward reflected neutral-beam sources with two-grid inductively coupled plasma (ICP) ion gun and with three-grid ICP ion gun. The diameter of the ion guns was 15cm, the grid hole size of the both grid systems was 2mm, and the openening percentage of the grid was about 47%. The rf power applied to the ion gun was 300W (13.56 MHz). The ions from the plasma in the gun were extracted using the grid assembly.