Development of a compact water-cooled surface wave plasma source for remote plasma processing

H. J. You, W. I. Choo

Plasma Technology Research Center, National Fusion Research Institute, Gunsan, Republic of Korea

A compact surface wave plasma source was newly developed for remote plasma processing such as chamber cleaning, dry etching(SiO_2, Si_3N_4, Silicon), photoresist stripping(SU-8), and decapsulation of microchips. The source was designed to be compact but to have high flow rate plasma generation and high gas decomposition rate so that it could bring higher radical generation, increased throughput, and uniform processing. In this presentation, we present results of microwave electric field simulations, and then we show experimental results on the source performances.

1. Introduction

As for cleaning process of unwanted deposits on processing chamber wall and its tooling, the most advanced cleaning method is so-called "remote plasma source cleaning(RPSC)". In the RPSC, input gases(i.e. NF_3) are supplied to a remote plasma source where they are dissociated into constituent atoms(F, N, F_2, and N_2), then the active species transported to the interior of the processing chamber. The first generation of remote plasma source was surfaguide-type microwave discharge since it has wide range of operating pressure and high rate of gas dissociation. However, the microwave source had some limitations on flow rate capability and hardware simplicity; The surfaguide discharge source used a dielectric tube as a discharge chamber, so the tube could not withstand some high level of plasma load. Also due to bulky set of supporting microwave hardware(tuning stubs, circulator/dummy load, and large-size high voltage power supply, it was difficult to have simple configuration and smaller footprint.

Therefore, the next generation of microwave remote plasma source should have higher flow rate capability and compactness, which allow for extendibility to faster, larger cleaning process and reduced complexity. In this presentation, a new compact microwave plasma source sustained by surface wave is introduced. We describe the design of the source and show the results of microwave electromagnetic simulations. Further, results of NF3 plasma experiments is given on plasma operation ranges and gas decomposition rates.

2. A Water-cooled Surface Wave Plasma Source

The source was designed to be compact but to generate high flow rate plasma with high gas decomposition so that it could result higher active species(radicals) generation and increased throughput. The above features were accomplished by an efficient microwave coupling and a water-cooled plasma region. As shown in Fig. 1, the microwave is fed by WR340 waveguide. High microwave field is coupled to a plasma region by a coupling rod that is intruded into the wide side of the waveguide inner wall. Plasma is mainly generated in a conical crucible-type alumina chamber. The conical end of the plasma chamber is made to be located in the opposite side of the waveguide and face with the coupling rod. The coupling rod is water cooled. The crucible plasma region is surrounded by an aluminium nitride(AlN) cover(shaped like a cap), and downstream plasma region is also by a tightly fitted aluminium(Al) jacket. Here, both surrounding structures are actively cooled by water again. Therefore, inside and outside of the waveguide, the plasma chamber can be efficiently cooled by the AlN cover and the Al jacket, respectively. It is worth noting that the microwave coupled to plasma region does not meet any obstacles like cooling media as previous surfaguide sources do. This is why the present source has efficient plasma generation.

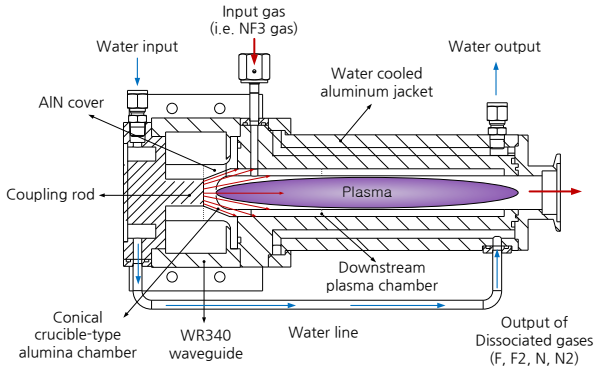

Fig. 1. A sectional view of the compact water-cooled surface wave plasma source.

It was found that the generated plasma can be sustained from 1 kW of microwave power with 10 slm NF_3 gas. Typically, higher power gives brighter plasma generation and higher gas decomposition. The measured decomposition rate was ranged from 80 to 99 % with 1-3 kW.