Surface Reflection Hyperthermal Neutral Stream Source

Christopher A. Nichols

College of William & Mary, Department of Applied Science, 1996
Field: Surface and Interface, Degree: Ph.D.
Advisor: Dr. Dennis M. Manos

Abstract

A novel source of hyperthermal (1-30eV) reactive neutral based on the surface-reflection-neutralization technique is described. This source is potentially capable of minimizing the charge-induced damage associated with plasma based semiconductor processing steps. The goal of this thesis is to investigate the issues involved in scale-up of this technology for processing of 8” diameter wafers used today in the semiconductor industry. This includes modeling the plasma ion source and trajectory simulations of the reflected neutral flux. A prototype source was constructed for experimental verification of the plasma model.

An inductively coupled plasma (ICP) source is used to provide a source of reactive ions. The ions are neutralized and reflected through interaction with a biased metal plate. These reflected neutrals are directed at a wafer to be etched (for feature delineation) or cleaned (removal of etch residue).

The plasma source is modeled with a global (volume averaged) power deposition model to determine plasma densities at the reflector plate. The modeled values are compared to measurements of a prototype neutral stream source. Plasma parameter measurements are carried out using Langmuir single probes. It is found that the plasma densities in the upstream plasma source and at the reflector plate agree well (within 10%) with the model.

Several models of reflected neutral trajectories are used to determine the final flux characteristics at the wafer. 2-D and 3-D trace models were first used to understand pressure effects on flux and angular distributions. The 2-D model was also used to model these characteristics for various plasma source configurations and reflector plate shapes. A full 3-D Monte Carlo simulation was used to explore reflected neutral energy and angular distributions at the wafer. 3-D flux maps at the wafer are also determined to understand flux uniformity. It is found that in the geometry considered in this work, background pressure plays a key role in delivering hyperthermal neutrals to the wafer. Energy and angular distributions are altered severely as the neutrals traverse the background gas and plasma. The results from these models have suggested a number of improvements which can be incorporated in the next-generation prototype neutral stream source.