Ion Density and Temperature Distributions in an Inductively Coupled High-Plasma Density Reactor

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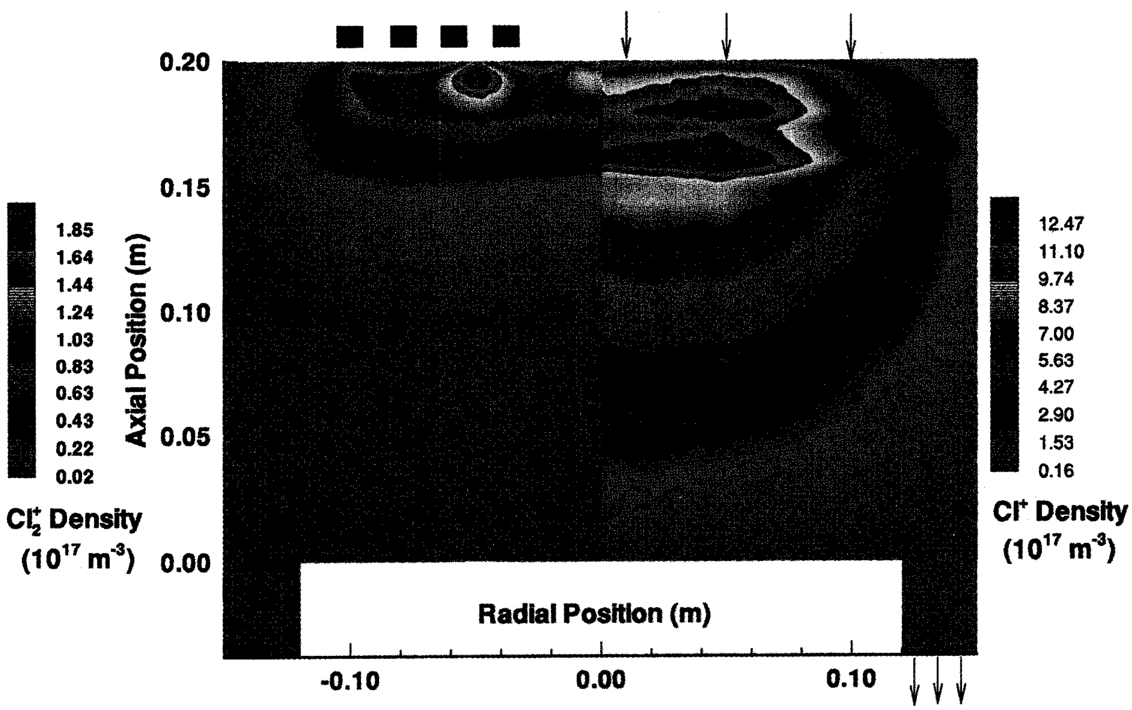

Fig. 1. Molecular (left) and atomic (right) chlorine ion density distributions. A schematic of the (axisymmetric) induction coils is shown on the left side of the figure. The feed gas and pumping locations (also axisymmetric) are shown on the right side of the figure.

***Abstract*—In a low-pressure plasma, the ion temperature T_i is comparable to the gas temperature T_g in regions of weak electric fields, but T_i can be more than an order of magnitude higher than T_g near the plasma sheath.**

LOW GAS pressure (<6 Pa) inductively coupled plasma (ICP) reactors are capable of satisfying the requirements for fabricating the next generation of microelectronic devices: uniform processing, anisotropic and low damage etching, and high throughput. In this paper, we report on the ion density and temperature distributions in an ICP with a planar induction coil above the dielectric roof of the reactor.

A schematic of the plasma chamber is shown in Fig. 1. The reactor's inside diameter is 0.25 m, and the quartz window (not shown) is 0.2 m above the 200-mm diameter wafer. Pure chlorine gas enters in the form of three concentric rings at the top, and the spent gas along with the reaction products are pumped out through an annular ring at the bottom of the reactor. The total gas flow rate is 140 sccm, and the flow is distributed proportionately to the radius of the ring.

Direct simulation Monte Carlo (DSMC), a particle-based technique [1], was used in conjunction with a fluid plasma simulation to study etching of a polysilicon wafer under a nominal pressure of 1 Pa and total power deposited by the induction coil of 3 kW. The gas and surface chemistry as well as the details of the DSMC simulation have been reported before [2]. To our knowledge, there have been no simulation results on gas temperature, and especially on ion temperature, reported in the literature so far; the ion temperature is usually assumed equal to the gas temperature. Experimental measurements and the results shown below contradict this assumption. Both images shown below were generated using the commercial software package Tecplot®.

Fig. 1 shows the atomic (right) and molecular (left) chlorine ion density distributions in the reactor. The dominant ion is

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