RF Inductive Discharge Source Design for Large Area Processing

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There is currently a demand for plasma processing equipment for large-area substrates driven by needs for the microelectronics industry and flat panel displays. Reactors in operation in commercial fabs today process silicon wafers 150-200 mm (6-8") in diameter, but this size will to increase to 300 mm (12") in the next few years. In the case of flat panel displays, substrates are even larger with dimensions greater than 500 mm on a side. Increasing reactor size for uniform processing of larger substrates is not a simple matter of making everything larger, and reactor development presents several major challenges. Some of these challenges, as they apply to the specific example of planar inductively coupled plasma (ICP) sources, are the topic of this paper.

Planar ICPs are a natural choice (although not the only one) for processing of large area substrates. In commercial reactors in use for etching 150 mm and 200 mm diameter wafers, current at 13.56 MHz is driven through a flat spiral antenna separated from the process chamber by a quartz window. This creates an "image" current in the plasma resulting in inductive coupling of power. Straightforward scaling of this configuration involves increasing the outer diameter of the spiral antenna as well as the diameter of the quartz window.

There are several problems specific to increasing window and antenna size, in addition to other problems associated with scale-up such as gas delivery and substrate handling. An increase in window area requires an accompanying increase in window thickness to maintain structural integrity. The separation between the antenna and the plasma is also increased, with the result that a higher antenna current is required to couple a given amount of power into the discharge. At the same time, going along with an increase in size of a spiral antenna is an increase in inductance. The problem arises because these two effects significantly increase the voltage requirements for the antenna, and therefore increase the degree of capacitive coupling to the discharge, possibly changing its character significantly in undesired ways.

In this paper, we explore some of the issues associated with discharge scale-up and introduce some alternatives to the conventional ICP design that have some advantages for large area discharges. To address the issue of antenna inductance, we introduce lower inductance alternatives to the spiral designs. Results of extensive characterization of power coupling to the plasma will be discussed, particularly in the context of optimization of antenna design. In addition, a combined window/electrostatic shield that reduces window thickness and blocks capacitive coupling will be discussed.

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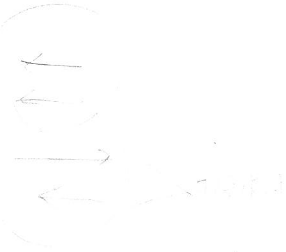
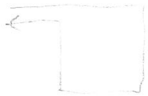
Antenna



ladder

loop



serpentine

[illegible]

Thick window

ファラデーシールドへの power coupling