

Large-Area Permanent-Magnet ECR Plasma Source

This device is a good source of ions for plasma processing applications.

John H. Glenn Research Center, Cleveland, Ohio

A 40-cm-diameter plasma device has been developed as a source of ions for material-processing and ion-thruster applications. Like the device described in the immediately preceding article, this device utilizes electron cyclotron resonance (ECR) excited by microwave power in a magnetic field to generate a plasma in an electrodeless (noncontact) manner and without need for an electrically insulating, microwave-transmissive window at the source. Hence, this device offers the same advantages of electrodeless, windowless design — low contamination and long operational life.

The device generates a uniform, high-density plasma capable of sustaining uniform ion-current densities at its exit plane while operating at low pressure [$<10^{-4}$ torr (less than about 1.3×10^{-2} Pa)] and input power <200 W at a frequency of 2.45 GHz. Though the proto-

type model operates at 2.45 GHz, operation at higher frequencies can be achieved by straightforward modification to the input microwave waveguide. Higher frequency operation may be desirable in those applications that require even higher background plasma densities. In the design of this ECR plasma source, there are no cumbersome, power-hungry electromagnets. The magnetic field in this device is generated by a permanent-magnet circuit that is optimized to generate resonance surfaces. The microwave power is injected on the centerline of the device. The resulting discharge plasma jumps into a “high mode” when the input power rises above 150 W. This mode is associated with elevated plasma density and high uniformity.

The large area and uniformity of the plasma and the low operating pressure

are well suited for such material-processing applications as etching and deposition on large silicon wafers. The high exit-plane ion-current density makes it possible to attain a high rate of etching or deposition.

The plasma potential is <3 V — low enough that there is little likelihood of sputtering, which, in plasma processing, is undesired because it is associated with erosion and contamination. The electron temperature is low and does not vary appreciably with power.

This work was done by John E. Foster of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17561-1

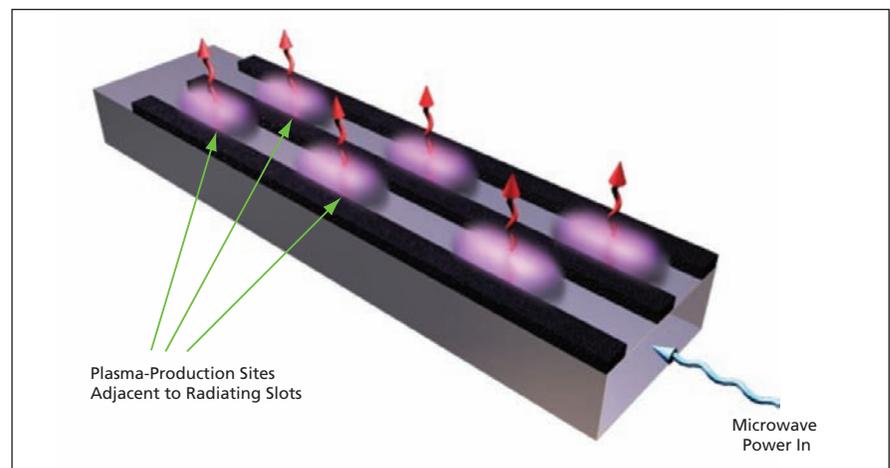
Slot-Antenna/Permanent-Magnet Device for Generating Plasma

Characteristics include uniformity of plasma, scalability, versatility, and long life.

John H. Glenn Research Center, Cleveland, Ohio

A device that includes a rectangular-waveguide/slot-antenna structure and permanent magnets has been devised as a means of generating a substantially uniform plasma over a relatively large area, using relatively low input power and a low gas flow rate. The device utilizes electron cyclotron resonance (ECR) excited by microwave power to efficiently generate plasma in a manner that is completely electrodeless in the sense that, in principle, there is no electrical contact between the plasma and the antenna. Plasmas generated by devices like this one are suitable for use as sources of ions and/or electrons for diverse material-processing applications (e.g., etching or deposition) and for ion thrusters.

The absence of plasma/electrode contact essentially prevents plasma-induced erosion of the antenna, thereby also helping to minimize contamination of the plasma and of objects exposed to the plasma. Consequently, the operational lifetime of the rectangular-waveguide/slot-antenna structure is long and the lifetime of the plasma



Plasma is Produced at sites adjacent to matched radiating slots in a rectangular-waveguide/slot-antenna structure.

source is limited by the lifetime of the associated charged-particle-extraction grid (if used) or the lifetime of the microwave power source.

The device includes a series of matched radiating slot pairs that are distributed along the length of a plasma-

source discharge chamber (see figure). This arrangement enables the production of plasma in a distributed fashion, thereby giving rise to a uniform plasma profile. A uniform plasma profile is necessary for uniformity in any electron- or ion-extraction electrostatic optics. The