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Fast magnetization of a high-to-low-beta plasma beam

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3P3-13

A Microwave Generated Plasma for Ion Implantation Studies*

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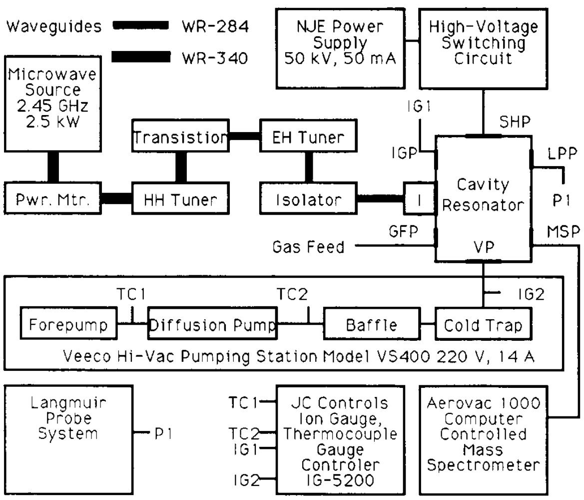
Industrially acceptable methods of plasma ion implantation not only require an efficient means of switching the negative high-voltage pulses,[1] but also require an energy efficient plasma generation system. To do this, a non-magnetized microwave generated plasma was designed and is being built. Pictured below is the block diagram. The power source is from a Model PPS-2.5 AS 2500-W, 2.45 GHz Varian (Eimac) microwave power pack with a WR-340 waveguide port. Both the forward and reflected power is measured with a Model EW3-DPM3S Varian power meter. A Model EW3-HH Varian HH tuner (power matching device) is included for impedance matching. Next, a Model GS315 Gerling RMS step transistion, which steps WR-340 (S band) waveguide to WR-284 waveguide, is included since there are many more microwave components available in the WR-284 size. Next, a standard EH tuner is included which is used for most of the matching since the plasma is a changing load. Then, an isolator is included to minimize the reflected power back on the source if the plasma extinguishes. "I" in the diagram denotes the microwave interface constructed from fused quartz including an E-probe launcher. The cavity resonator includes several ports: sample holder port (SHP), Langmuir probe port (LPP), mass spectrometer port (MSP), vacuum port (VP), gas feed port (GFP), and ion gauge port (IGP). The cavity was designed such that several TE modes (other than the dominant mode) will be set up in the resonator to give a quasi uniform field distribution so that the plasma can have an approximately uniform number density. The surface of the cavity resonator will have many permanent magnets fixed to it to help confine the plasma.



[1] Keebler, P. F., John E. Crowley, and J. R. Roth: "A High-Voltage Switching Circuit for Rapid Plasma Ion Implantation", APS Bulletin, Vol. 34, No. 9 (1989) p. 2021.

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3P3-14

Fast Magnetization of a Low to High Beta Plasma Beam

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We have studied the magnetization of a high-β, hydrogen-plasma beam injected into a vacuum transverse magnetic field ($\beta \equiv$ plasma energy density/magnetic field energy density ≥ 1). Nominal parameters were: $T_i \leq$ eV, $T_e \leq 5$ eV, $n < 3 \times 10^{13}$ cm^{-3}, $v_i \leq 7 \times 10^6$ cm/s, $t_{pulse} < 70$ µs, $B_z \leq 300$ G. Plasma beam characteristics were measured for a wide beam, $a/\rho_i \leq 35$, and a downstream distance, $x \leq 300\ \rho_i$, where a is the beam radius, x is the downstream distance, and ρ_i is the ion gyroradius. We observe a brief initial state of diamagnetic propagation followed by $\underline{E} \times \underline{B}$ (magnetized) propagation; $\underline{E} \times \underline{B}$ propagation is accompanied by beam compression transverse to $\underline{B}$ with as much as a factor of four increase in density and a slight drift of the beam in the direction of the ion Lorentz force. At high fields, $B_z = 200$–300 G, the observed magnetic field diffusion time is much faster than calculated from classical Spitzer conductivity and is more of the order of the diffusion time based on Hall conductivity.

3P3-15

PRELIMINARY CONSIDERATIONS AND EXPERIMENTS TO OBTAIN HIGHER BRIGHTNESS OF PULSED ION BEAMS WITH BUNCH*

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One of the still-important issues of the intense pulsed ion beams for inertial confinement fusion compared with the lasers is to get the higher ion beam brightness with all kinds of considerable efforts. So that, we tried preliminary considerations and experiments in this direction with the method of beam bunch.

Although almost all of getting the higher beam brightness are based on the geometrical focusing of the beams extracted from concave anode surfaces until now, it is hoped to bunch the beams during the beam transport to get still higher brightness of the beams. So that, we adopted the following methods to gather the fundamental data to prepare the future experiments of beam bunchings.

To bunch the beams, we need (1)focusing type ion diodes without turn on delay times, (2)large current channels to transport focused ion beams and (3)pulsed power generators to supply high voltage to the ion diodes which is suitable for the beam bunching. In these regards, we operated a pulsed ion source with a so called active anode, and we designed a small channel to be assembled together with our cryogenic ion diode. Then we also measured the particle distributions within the ion diode which had large effects to the characteristics of the beam focusing and the beam transport.

To extract ion beams without turn-on delay times and to exclude the disturbances by the neutral