CHARACTERISTICS OF ECR ION SOURCE FOR OPTICAL PUMPING TYPE POLARIZED ION SOURCE

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Abstract

An optical pumping type polarized ion source has been developed at KEK. A 16.5 GHz ECR ion source was adopted as an H^+ ion source. The properties of ECR ion source i.e. ion beam intensities, proton ratios, plasma electron temperature and plasma densities were measured.

Fig. 1 shows a schematic setup of polarized ion source using the 16.5 GHz ECR (Electron Cyclotron Resonance) ion source. The ECR ion source consists of a cylindrical plasma chamber and three solenoid coils. 1 ∿ 2 kW microwave power was produced by a coaxial magnetron (JRC, M1408), which was modified for tolerating long pulse width (∿ 1 msec) and high repetition rate (20 Hz) operations. The microwave power was fed into the plasma chamber through a thin microwave window for vacuum sealing. The plasma chamber is made of stainless steel. Three solenoid coils form magnetic mirrors (mirror ratio ∿ 2) and the field at the beam extraction and Na cell region is 0.9 T. Low energy (2 ∿ 5 keV) H^+ ion beam was extracted by multi-slit electrodes forming accel.-decel. system. Total extracted ion current was 220 mA at 3.7 keV and the beam current of 50 ∿ 60 mA was measured at the exit of Na cell (10 cm away from extractor) by a 1 cmϕ Faraday cup as shown Fig. 2.

Measured proton ratio was more than 60 % at the distance of 40 cm aparting from the multi-slit electrodes. Hydrogen pressure in the plasma chamber was less than 1×10^{-4} Torr in normal operation. It affected strongly proton ratio. Fig. 3 shows the measured values of proton ratio as a function of the hydrogen gas pressure.which was measured at the head of a turbomolecular pump. As the pressure increased, the proton ratio decreased. A higher proton ratio of 70 % was obtained by optimising the source parameters.

Langmiur probe for the measurement of plasma parameters of the ECR ion source was placed at 10 mm separated for axis of plasma chamber. The electron temperatures and the plasma densities were measured for the two types of the plasma chamber; one is of introducing the microwave transversely to the magnetic field and the other of longitudinally. The results are summarized in Figs. 4 and 5. Hydrogen pressure in Fig. 4 was measured at the plasma chamber and that in Fig. 5 was at the head of the turbomolecular pump. The plasma densities in these figures were separately calculated from the electron saturated current (Ies) and the ion current (Ii). As seen in figures, the electron temperature decreased abruptly as the hydrogen pressure increased. In normal operation, the electron temperature and the plasma density were 23 eV and 10^{12} n/cm^3 respectively.

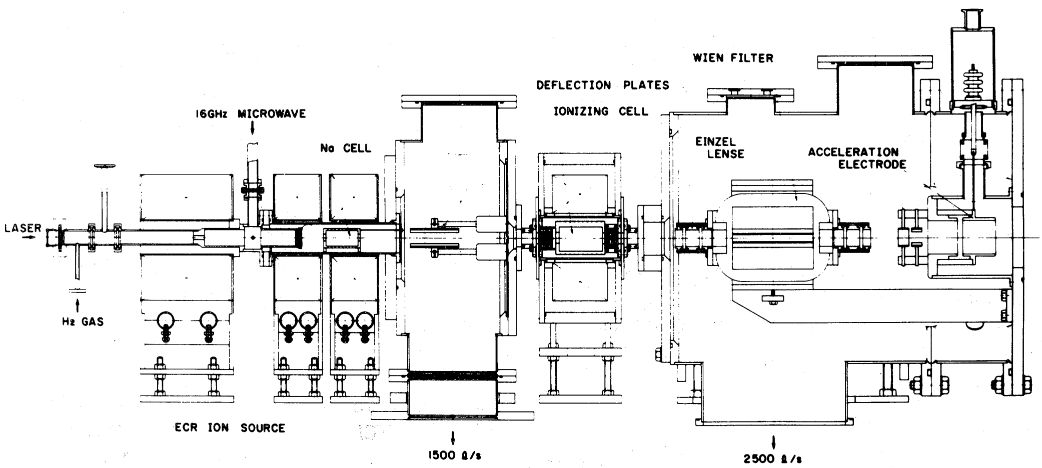

Fig.1. Schematic setup of polarized H^- ion source.

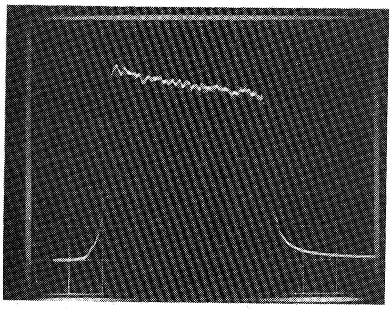

Fig.2. Ion beam current of ECR ion source.

H : 50 μs/div.
V : 10 mA/div.

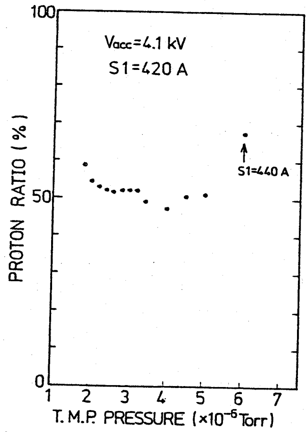

Fig.3. Proton ratio of ion beams as a function of hydrogen pressure

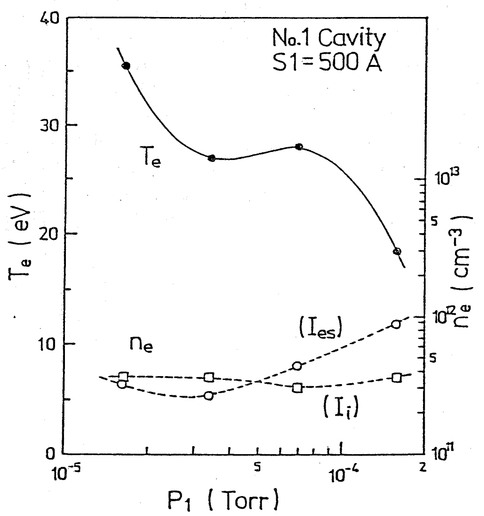

Fig.4. Electron temperature and plasma density versus hydrogen pressure for No.1 plasma chamder.

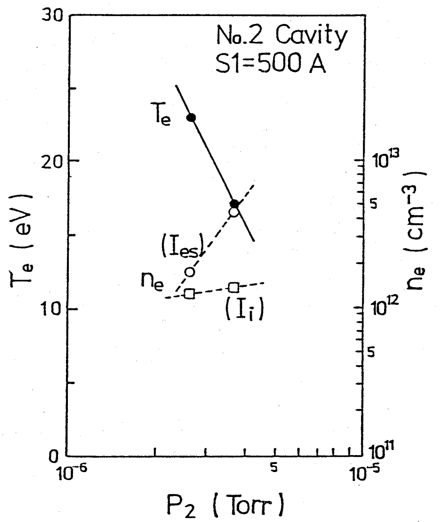

Fig.5. Electron temperature and plasma density versus hydrogen pressure. for No.2 plasma chamber.