Abstract

This thesis is devoted to characterization of the plasma in the large volume plasma system (LVPS) produced by multiple compact electron cyclotron resonance plasma sources (CEPS). The experiments were conducted in a stainless steel chamber of inner radius \( \approx 50 \) cm and maximum height of 150 cm. The work began with an extensive literature survey of the studies conducted on large volume systems, from which it was possible to conclude that in spite of different methodologies adopted for producing uniform plasmas in these systems, the problem of uniform density plasmas still needs to be addressed. Thus the primary aim of the present work was to design and undertake suitable experiments that would throw light on this problem.

The LVPS set up in the laboratory, is assembled by stacking source and spacer sections along the chamber axis. Source sections have appropriate ports for mounting of the CEPS in azimuthally symmetric manner. Plasma production in the LVPS is based on ECR mechanism. In order to have desired magnetic field, permanent magnets have been placed over each CEPS. The magnetic field orientation of all the magnets in a single source plane was decided in such a way that the resultant field produces cusp field configuration inside the LVPS. However, the field well inside the LVPS is quite weak (\( \approx 20 \) Gauss).

The particular attention was paid to the plasma diagnostics from which detailed information regarding the different plasma parameters would be obtained. A detail discussion is presented on the techniques used for analyzing the LP data for obtaining bulk plasma density, the bulk electron temperature, the warm electron density and temperature, and the plasma potential. Bohm’s theory has been used for computing the plasma density. To this end, Langmuir probes (LP) were fabricated and mounted on
different ports of the spacer section. Particular attention was also paid to analysis of the LP data, since it was only from a careful analysis of the latter that one could detect the presence of a separate non-thermal population of high-energy electrons and demonstrate high uniform density plasmas inside the LVPS.

In order to understand flow of plasma from source section into the LVPS, it was decided to study single CEPS separately. For this purpose, single CEPS was mounted on another small chamber and a LP was installed for plasma characterization in line of the CEPS. Plasma characterization studies were carried out at different pressures and powers. It was observed that CEPS acts as a source of warm electrons which are responsible for plasma formation in the system.

Following the study on the single CEPS, a series of characterization experiments were conducted on the LVPS under different configurations of CEPS, source and spacer sections. These experiments were performed under the variation of microwave power and operating pressure. Using LP diagnostics, it was possible to conclude that plasma density remains fairly uniform inside the system and decreases marginally close to the chamber wall and this uniformity increases with increase in number of sources. It was seen that there is a warm electron population ($\approx 70$ eV) present in the plasma and bulk plasma density seems to be always track down warm electron density profile. It was concluded that this warm electron population is responsible for the maintaining plasma in the LVPS.