Impedans Langmuir Probe used to improve performance of an RF Plasma implanter for creating high concentration of dopants

Published in Journal of Current Applied Physics

Jong Jin Hwang et al, Current Applied Physics 65 (2024) 53–59
https://doi.org/10.1016/j.cap.2024.06.004

Introduction

The Langmuir probe is a versatile diagnostic tool widely used in plasma physics to measure key plasma parameters such as electron temperature, electron density, and plasma potential. Its applications span various fields, including fusion research, semiconductor manufacturing, and space physics, where understanding plasma behavior is crucial for optimizing processes and improving device performance. The Langmuir probe's ability to provide real-time, localized measurements makes it invaluable for both experimental studies and practical applications in plasma technology.

A recent article in the Journal of Current Applied Physics showcased how the Impedans Langmuir Probe was used in an RF ion source. The probe's measurements were crucial in developing a more power-efficient RF ion source with higher ion density, which is important for doping in semiconductor production.

Experimental setup

The test chamber used to measure the ignition and density of plasma in the ICP RF source is shown in Figure 1. Argon gas is used to create the plasma. Inside the ceramic tube, surrounded by the RF antenna, the plasma forms, which is shown in red to indicate the plasma generation area. A magnet is placed near the tube to increase the magnetic field, which helps boost plasma density. The top of the chamber chamber is mounted with a glass viewport for real-time monitoring of the plasma. Additionally, a DC source with an inductively heated cathode (IHC) was set up for comparing plasma properties.

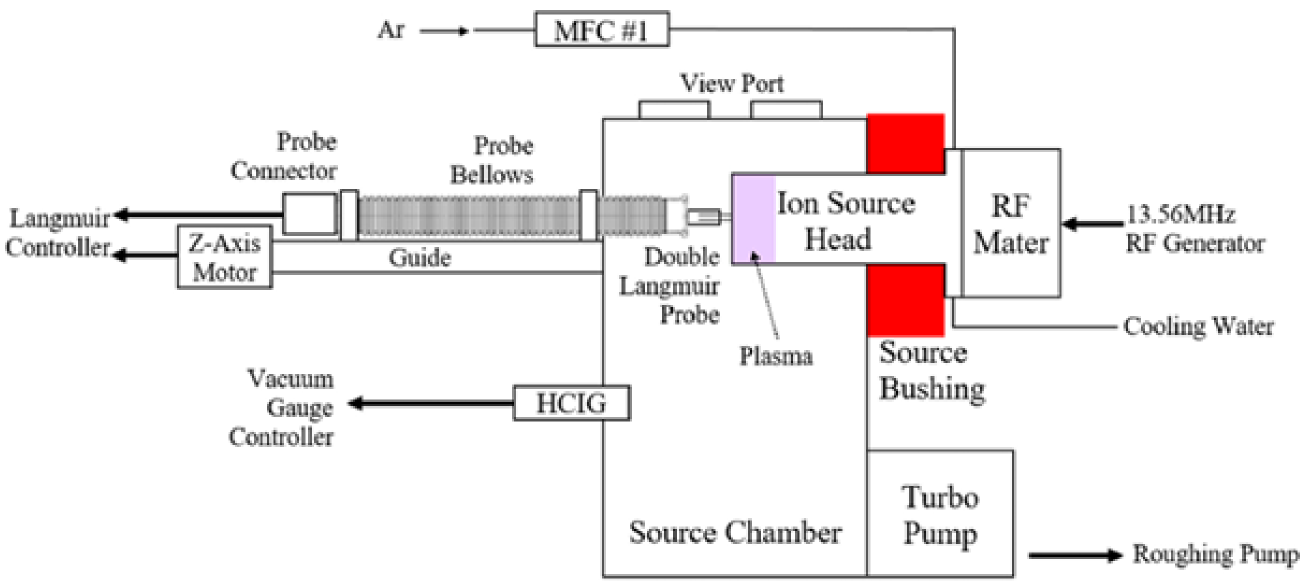

Figure 1 System diagram of the test chamber with RF Ion Source Head and Langmuir probe.

A Langmuir probe (ALP-150, IMPEDANS) was installed by connecting the bellows to the back of the source chamber to compare the internal plasma characteristics with those of the IHC DC source. A double probe with a 0.5 mm diameter tip was used. The probe's alignment was controlled by a DC motor to move it along the chamber's z-axis, thereby facilitating the measurement of plasma characteristics.

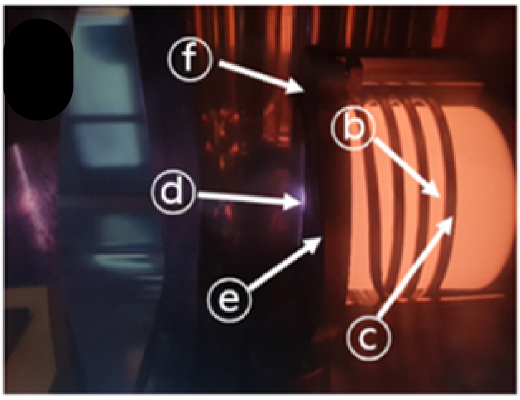

Figure 2 ICP RF source with Ar plasma ON (Ar flow rate of 3 sccm, RF 600 W) and showing the necessary component (b) ceramic tube, (c) RF antenna, (d) arc slit, (e) arc slit cover, and (f) arc slit supporter.

Results

Ion density was measured within the arc slit of both the ICP RF and IHC DC sources using a double Langmuir probe at same locations. Figure 3(a) shows the I–V curve measured using the Langmuir probe of ICP RF 900 W and IHC DC 895 W as an example. Figure 3(b) shows the ion density measurements obtained at different RF power levels, varying from 700 to 900 W, with the source magnet set at 4 A. The evaluation was conducted using 3 sccm of Ar gas, which is a common parameter for assessing the conditions of commercial implanters. The DC power levels were measured across a range similar to that of the ICP RF source, ranging from 682 to 895 W.

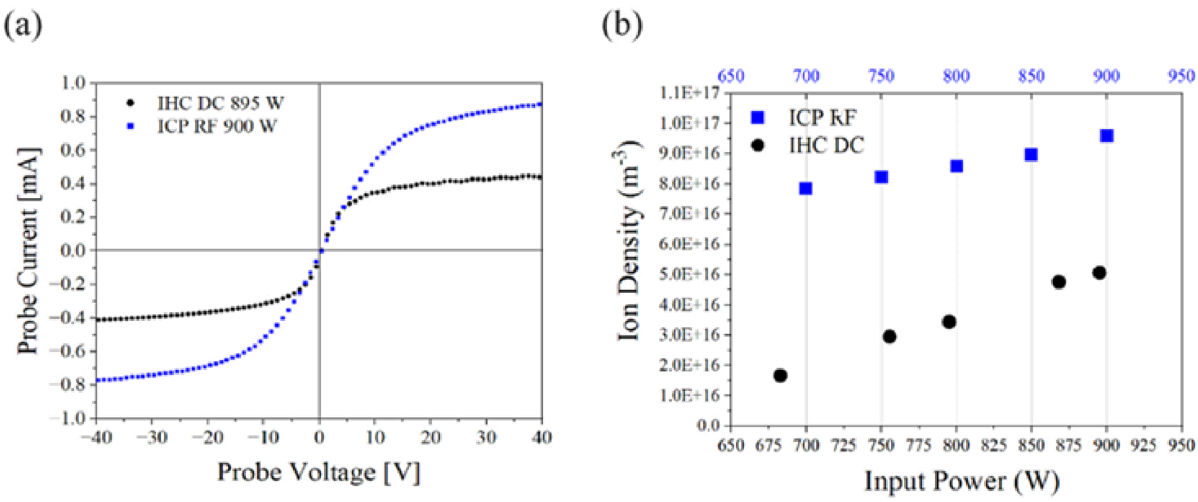

Figure 3 Ar flow rate of 3 sccm comparison between the IHC DC and ICP RF sources. (a) Langmuir probe I–V curve, (b) ion density.

A linear relationship was observed where ion density increased proportionally with input power in both cases. However, the ICP RF system achieves a correspondingly higher plasma density within the pressure range suitable for plasma generation.

Summary

Langmuir Probe measurements provided valuable insight into the performance of ICP RF ion source intended for commercial ion implanters. The measurements indicated that the newly developed ICP RF ion source exhibited significantly superior performance compared to that of the conventional IHC DC ion source.

Utilizing Impedans' Langmuir Probe to measure ion density offers direct insights to optimize the performance of RF ion sources and validate their suitability for commercial applications which will be essential for advancing ion implantation technology.

To know more about Impedans Langmuir Probe click here