紧凑型微波 ECR 等离子体源的设计及其特性研究

柴 昊[1],贾军伟[1],王 斌[2],李 鹏[2],崔 爽[2],冯 旭[3],
李 伟[1],刘 展[1],李绍飞[1],陈 权[1]
(1.北京东方计量测试研究所,北京 100094;2.北京空间机电研究所,北京 100076;
3.北京空间飞行器总体设计部,北京 100094)

摘 要:地面电推进试验、星载 Langmuir 探针地面标定等航天任务,均对等离子体参数的校准提出了需求。目前,等离子体参数的校准主要是在稳定的等离子体环境中,通过被测仪器与标准进行量值比对的方式实现,因此,获得稳定的等离子体环境是开展校准技术研究的重要前提。微波 ECR 源产生的等离子体具有均匀、稳定、可调节范围宽等特点,十分适合应用于等离子体校准中。本文设计研制了永磁型微波 ECR 等离子体源,并对该源的特性进行了实验研究,获得了该源的空间分布特性、稳定性实验结果。实验结果表明:研制的紧凑型微波 ECR 源稳定性、重复性均在 10%以内,具有作为标准源应用于等离子体校准的潜力。

关 键 词:微波 ECR 源;等离子体校准;空间分布;稳定性
中图分类号:TB79 **文献标识码**:A **文章编号**:1002-0322(2021)01-0006-04
doi:10.13385/j.cnki.vacuum.2021.01.02

Design and Characteristic Study on Compact Microwave ECR Plasma Source

CHAI Hao[1], JIA Jun-wei[1], WANG Bin[2], LI Peng[2], CUI Shuang[2], FENG Xu[3],
LI Wei[1], LIU Zhan[1], LI Shao-fei[1], CHEN Quan[1]
(*1.Beijing Orient Institute of Measurement and Test, Beijing 100094, China;*
2.Beijing Institute of Space Mechanical and Electricity, Beijing 100076, China;
3.Beijing Institute of Spacecraft System Engineering, Beijing 100094, China)

Abstract: Space missions such as electrical propulsion experiment and Langmuir probe payload calibration demand the plasma parameter calibration in order to ensure the accuracy of the measurement results. At present, the calibration of plasma parameters is mainly achieved in a stable plasma environment through comparison of the instrument and the standard. Therefore, obtaining a stable plasma environment is a fundamental requirement for the study of plasma calibration. The microwave ECR source has the characteristics of uniformity, stability and wide adjustable range, which is quite suitable to apply in the plasma calibration. In this paper, a compact permanent magnetic microwave ECR plasma source was designed and studied, and its spatial distribution and stability were obtained. The experimental results show that the stability and repeatability of the microwave ECR source used in this experiment could achieve less than 10%, which has potential to be applied as the standard plasma source for the plasma parameter calibration.

Key words: ECR source; plasma calibration; spatial distribution; stability

随着低温等离子体技术在航天任务中得到广泛应用,对等离子体参数测量结果的准确性及其量值溯源性受到了广泛的关注。例如,在地面电推进试验中,需要对电推进产生的等离子体羽流参数进行准确的测量,以评估等离子体与航天器相互作用;在星载 Langmuir 探针地面标定试验中,需要在地面模拟的稳定等离子体环境中,对 Langmuir 探针进行地面标定。为保证模拟产生的等离子体环境满足使用要求,需要在地面对涉及的等离子体参数进行准确测量以及可靠的量值溯源。目前,国内有航天 514 所开展了低密度等离子体环境下的 Langmuir 探针测试及其校准技

收稿日期:2020-02-20
作者简介:柴昊(1988-),男,山西省忻州市人,硕士,高级工程师。 **通讯作者**:贾军伟,高级工程师。