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Advancements in the Antenna Based Miniaturized 2.45 GHz Permanent Magnet ECR Ion Source at Peking University

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The 2.45 GHz electron cyclotron resonance (ECR) ion source offers several advantages, including high ion current intensity, low ion beam emittance, excellent stability, a relatively simple structure, cost-efficient, and an extended operational lifespan. Consequently, it is the preferred choice for generating high-intensity ion beams in various ion beam facilities. Nowadays numerous compact devices such as neutron tubes, ion thrusters, EUV lithography cleaners, and medical accelerators require the miniaturized plasma sources. Therefore, promoting the miniaturization of the 2.45 GHz ECR ion sources is crucial for their broad range of applications. However, the miniaturization of ECR ion sources faces limitations due to challenges associated with RF transmission and microwave coupling. Therefore, innovative methods for microwave coupling beyond ridge waveguide or microwave window are urgently needed. Recently, an antenna based microminiature 2.45 GHz ECR ion source was designed and tested at Peking University (PKU). This source features a discharge chamber diameter of only 13 mm and has a body weight of 1.5 kg. Numerical models were developed to optimize the antenna structure and characterize plasma properties effectively. Initial tests were carried out on PKU ion source test bench and 2.2 mA hydrogen current load can be achieved with 10 W RF power in DC mode. When microwave power increased to 40 W, the current went up to 11.2 mA with a H^+ ratio of 47.1%. Furthermore, long-term operation confirmed the stability of this novel source design.

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