DESIGN AND OPTIMIZATION OF A DIODE-TYPE MAGNETRON INJECTION GUN FOR TRI-FREQUENCY GYROTRON

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ABSTRACT

This study introduces an innovative Diode-type Magnetron Injection Gun (D-MIG) tailored for a tri-frequency gyrotron, targeting operation at 42 GHz, 84 GHz, and 95 GHz, each with power outputs exceeding 200 kW. To address the gyrotron's specifications and various technological constraints such as wall losses and voltage depression, the $TE_{6,2}$, $TE_{10,4}$, and $TE_{12,4}$ modes are carefully chosen for operation. The selection of a diode-type magnetron injection gun is based on its simplicity and effectiveness [1]. In the context of a multi-frequency gyrotron, while the physical dimensions of components designed for one frequency remain constant, parameters like beam radius and compression ratio vary with the frequency. Achieving these adjustments involves modifying the magnetic field strength and profile in the device, necessitating changes in external currents applied to the solenoid coils [2]. Electron emission from the cathode results in the formation of a gyrating annular beam within the magnetic field environment. Precise optimization of both the D-MIG and the magnetic field distribution is crucial to produce a high-quality beam with minimal electron velocity spread, facilitating efficient power transfer to the desired operating mode [3]. Initial determination of D-MIG parameters, such as cathode radius and emitter slant length, are carried out using Baird and Lawson's initial approximation and further optimized using the in-house code package GDS-2018 [4], [5]. Subsequent optimization is conducted through particle trajectory simulations using EGUN software, ensuring accurate prediction of beam parameters while integrating the required magnetic field profile [6]. A specialized four-solenoid magnet system is deployed to generate the necessary magnetic field distribution, comprising a central main coil and two auxiliary coils to establish the static magnetic field along the interaction cavity. Additionally, a dedicated gun coil positioned in the emitter region enables precise control of the magnetic field strength. The specific magnetic fields of operation are set at 1.62 T, 3.29 T, and 3.69 T. With an anticipated device efficiency approaching 45%, the electron beam radius measures 7.29 mm, 6.01 mm, and 6.52 mm at operating frequencies of 42 GHz, 84 GHz, and 95 GHz, respectively.

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