Ongoing Developments for the KIT 2-MW 170-GHz Coaxial Cavity Gyrotron Prototype

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ABSTRACT

Electron cyclotron resonance heating and current drive (ECRH&CD) is one of the major methods for plasma heating and stabilization in nuclear fusion devices. It offers excellent coupling to the plasma and a very good localization of the absorbed RF power inside the plasma. Karlsruhe Institute of Technology (KIT) is currently performing major developments for several nuclear fusion experiments which are using ECRH&CD. Among them, W7-X, ITER and future DEMO are the most promising. Gyrotrons are the unique RF sources which meet the extraordinary requirements for ECRH&CD of thermonuclear fusion experiments. RF output powers in the MW range, operating frequencies up to 170 GHz, and pulse lengths of several seconds up to continuous wave (CW) operation have been achieved already. Nevertheless, optimum current drive efficiencies for future nuclear fusion devices such as DEMO will require the development of gyrotrons operating at even higher frequencies (in the range from 200 GHz up to 300 GHz) offering excellent efficiencies and multi-MW levels of RF output power at the same time. To prevent mechanical antenna steering in the fusion machine, frequency step-tunable RF sources will be required for localized plasma stabilization.

In this work an inverse Magnetron Injection Gun (IMIG) [1] has been designed for the KIT 2-MW, 170-GHz coaxial cavity gyrotron [2]. The ambition is the possibility for implementation of a larger emitter ring, better cooling conditions and easier suppression of trapped electrons compared to the "conventional" MIGs used in today's gyrotrons. Considering the fundamental beam parameters, in the theoretical analysis an excellent beam quality has been achieved which results in a very low velocity spread. In addition, the IMIG fulfils the gun design criteria, which are published in [3]. In order to ensure a stable operation under hot condition, the thermomechanical behavior and material compositions were investigated and optimized. Additionally, the components were already manufactured with an excellent surface quality.

Furthermore, the development of a longer pulse 2 MW 170 GHz gyrotron is ongoing and an advanced water cooling system has been designed, especially, for the beam tunnel, cavity and launcher. One of the main specification of the project is a pulse length of 1 s and the conservation of the modularity of the gyrotron. Therefore an independent water cycle of each gyrotron component has been designed and verified with the multi-physics software *Comsol*.

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