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Overview of Recent Gyrotron R&D towards DEMO within EUROfusion Work Package Heating and Current Drive

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Within the Work Package Heating and Current Drive (WPHCD), coordinated by the Power Plant Physics and Technology Department of EUROfusion, detailed studies are ongoing, which cover three different systems for plasma heating and current drive. These are, namely, systems using electron cyclotron waves, ion cyclotron waves, and neutral beam injection. The studies are in line with the European Fusion Roadmap towards a demonstration power plant (DEMO). The work breakdown structure of WPHCD, launched in 2014, includes branches dedicated to the conceptual design of the electron cyclotron system, as well to R&D focused mainly on the microwave source, the gyrotron. Gyrotron R&D is a necessary step to bridge the gap between today's state-of-the-art gyrotrons and future gyrotrons for DEMO. Significant challenges are posed by the need for dual frequency (170/204 GHz) operation and/or frequency step-tunability of gyrotrons at a 2-MW power level, as well as by the requirements for significantly higher efficiency (> 60 %) and level of Reliability-Availability-Maintainability-Inspectability (RAMI). Gyrotron R&D within WPHCD is addressing those challenges by exploring innovative, promising approaches. In addition, and in order to keep the R&D relevant with respect to possible baseline changes and to alternative reactor configurations towards a future power plant, efficient MW-class gyrotron operation at higher (~240 GHz) frequencies is also investigated. This paper gives an overview of the recent progress of gyrotron R&D within WPHCD, driven by the aforementioned challenges and conducted along the following lines: (i) Experimental verification of coaxial gyrotron technology at longer pulses and design of a 2 MW 170/204/(238) GHz coaxial gyrotron, (ii) investigations on multi-stage depressed collector concepts to increase the overall gyrotron efficiency, (iii) development of large broadband diamond windows to allow for frequency step-tunability in steps of 2-3 GHz over a range of ~20 GHz, and (iv) advances on performance and reliability of gyrotron components to increase the RAMI level. Instrumental to the gyrotron R&D is the new Fusion Long Pulse Gyrotron Lab (FULGOR) at Karlsruhe Institute of Technology, a test stand able to support the development of continuous wave gyrotrons with a power of up to 4 MW at frequencies up to 240 GHz.

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