ELECTRIC FIELD SWEEPING CONCEPT FOR HIGH POWER GYROTRON COLLECTORS

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ABSTRACT

A high instantaneous thermal loading is generated in collectors of high power gyrotrons by the impacting spent electron beam. In today single-stage depressed collectors for continuous wave operation, this high instantaneous thermal loading is distributed with a magnetic field sweeping system onto a larger surface for a decreased time average thermal loading [1, 2]. The limiting factor is the relatively low sweeping frequency of up to 10 Hz (50 Hz) of the magnetic field sweeping system due to eddy currents, which are induced in the copper (stainless steel) collector wall. The change of temperature inside the collector is periodic with an amplitude that is higher the lower the sweeping frequency is. A high amplitude of the periodically changing temperature leads to a limited lifetime due to cyclic fatigue. Cyclic fatigue will cause deformation and cracks at the surface of the collector over time. The most critical locations in a conventional collector are the turning points of the magnetic field sweeping system.
A novel electric field sweeping concept is developed to increase the sweeping frequency by several orders of magnitude to achieve a lower periodic temperature variation at the collector wall of a high power gyrotron. An electrode system on the inside of the gyrotron is required to generate the electric field. The electrodes could be placed at the entrance of the collector. No shielding eddy currents are induced in the collector wall with the electric field sweeping concept. Thus the sweeping frequency is only limited by the electromagnetic resonance of the structure. The time-average power loading density and with it the average collector temperature could be increased with a higher sweeping frequency without compromising a reduced life time expectancy of the collector. The dimensions of the collector can be reduced and the water cooling circuit can operate more effectively if the average collector temperature is increased.

References

[1] M. Schmid, et al., Fusion Engineering and Design 82, 744–750, (2007)
[2] S. Illy, et al., Proc. Joint 32nd International Conference on Infrared and Millimeter Waves and the 15th International Conference on Terahertz Electronics, Cardiff, UK, 50–51, (2007)