A High-Power Gyrotron and high-power mm wave technology for Fusion Reactor

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In JAEA, the development of high-power mm wave technologies is underway for ITER, JT-60SA and DEMO. After achieving a 1 MW CW-relevant oscillation for the ITER gyrotron, the reliability of the gyrotron was tested. Repetitive operation at 0.8 MW, 400s was demonstrated for 10 shots in a series conducted every 30 minutes with no major trouble. The energy conversion efficiency was 56 % for every shots.

Output power from the window couples with the corrugated waveguide through the matching optics unit (MOU) in a manner similar to that of the ITER transmission line. Power was transmitted to the dummy load via the 40 m long evacuated waveguide with seven miter bends. Transmission efficiency from the gyrotron window to the dummy load is 92 %, when a loss of 4 % is included.

As for the equatorial launcher of ITER, the basic design has been determined. To reduce heat load on the steering mirror, quasi-optical transmission has been introduced. By expanding the beam size, the powers of adjacent beams overlap. Consequently, the peak power density on the mirror is reduced by 1/3 compared to conventional waveguide transmission. In addition, configuration of the transmission line has been simplified by minimizing the vacuum area in the launcher. A launcher mock-up was fabricated for a high-power test.

For the next stage, a gyrotron capable of operating at a higher oscillating mode is under development. In a short pulse gyrotron, power output of ~1.6 MW was demonstrated at $TE_{31,12}$. Using the same design cavity and magnetron injection gun (MIG), a long pulse gyrotron was fabricated, and the experiments confirming the capabilities of this gyrotron will be performed. This gyrotron will contribute to research into the higher mode oscillation, which will extend the lifetime of the cavity at higher power oscillation.

In the 110 GHz gyrotron for JT-60U, testing to access power increases has been carried out. Recently, high-power oscillation up to 1.5 MW for 1 s has been successfully attained with a gyrotron in a dummy load operation. The beam voltage and beam current were 86 kV and 62.8A, respectively. To increase the efficiency, the internal mode converter system has been improved.

For the DEMO reactor, it is anticipated that the mirror used in RF beam injection will not be applicable. Alternatively, the RF beam will be injected from the corrugated waveguide directly. To control the power deposition profile in the plasma, frequency control of the gyrotron is possible solution. For this purpose, the fast magnetic field control of a super conducting magnet coil was developed. Until now, frequency control of 0.4T/10sec has been demonstrated, which provides a prospect for fast frequency control of the gyrotron.