

§3. Research Study for New Evolution of Millimeter- and Submillimeter-Wave Applications

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i) Objectives A lot of RF(Radio Frequency) technologies from millimeter to sub-millimeter wave range have been utilized for plasma heating, current drive, plasma control and advanced plasma diagnostic methods in the nuclear fusion research. On the other side, applications of the electromagnetic waves in this wavelength regime are expanding to many fields. The high power handling technologies of the millimeter, sub-millimeter and THz region used in the fusion research will be more useful in the other research fields in special.

Applications of millimeter and sub-millimeter wave technologies spread over the material science, industrial, communication and medical areas. The extensive applied researches such as the advanced NMR and ESR, production of new materials, treatment for cancer are expected. On the other hand, the new technologies developed in these fields will be reflected in the improvement of efficiency and reliability in fusion systems and the high-precision diagnostics.

The objectives of this workshop are the information exchange among the researchers of millimeter and sub-millimeter wave and microwave technologies, the improvement of each millimeter wave system and development of combined research fields.

ii) Activities in FY2008 In this fiscal year, we intended to make intensive discussion of the latest research results and the new research trend of the generation, detection and application of millimeter and sub-millimeter waves.

First, we arranged and held a special session entitled "Workshop II: Millimeter-wave and THz Technologies" in the Global Congress on Microwave Energy Applications (GCMEA2008, MAJIC 1st), which was held in August 4th -8th, 2008, Ohtsu, Japan. In the special session, we had nine oral presentations by our collaborators (Idehara, Hangyo, Mitsudo, Oda, Shimozuma, Shidara, Kamada, *et al.*)¹⁾. A part of the proceedings will be published as extended papers in Journal of Microwave Power and Electromagnetic Energy.

Second, we had another workshop on plasma heating and diagnostics in February 20th, 2009 under the keywords of "The latest research results of millimeter and sub-millimeter wave applications to the nuclear fusion research". There were five presentations in the workshop as described below. The participants distributed over wide area related to the millimeter wave technology. About 25 members joined the workshop. The viewgraphs of each presentations were summarized in the CD-ROM for convenience.

Presentations:

1. "Slow-wave Cyclotron Maser Using Periodic Corrugated Waveguide with Large Diameter" by Dr. K. Ogura, Niigata University.
Theoretical and experimental researches on a high power 20 - 40 GHz oscillator by Cherenkov and slow wave cyclotron interactions were reported. The oscillator used a periodic corrugated cavity as a slow wave structure and a weekly relativistic (<100 keV) electron beam. The used corrugated cavity was machined in NIFS based on the same technology as the corrugated waveguides in the ECH transmission lines. The research work is an extended collaboration from this workshop.
 2. "Development of a High Power Sub-THz Pulse Gyrotron" by Drs. Y. Tatematsu and T. Notake, Univ. of Fukui, FIR FU.
 3. "The First Trial of Collective Thomson Scattering using a High Power 77GHz Gyrotron" by Dr. S. Kubo, NIFS.
The Collective Thomson Scattering (CTS) is a powerful diagnostic tool to measure an ion temperature and a distribution function of high energy ions in the fusion plasmas. Dr. Tatematsu presented the development of a 400 GHz high power gyrotron for CTS because the background Electron Cyclotron Emission (ECE) noise is low enough because of its high frequency. Dr. Kubo reported a preliminary result of CTS using a 77 GHz gyrotron in LHD experiments. This theme is also one of the collaborative researches of this workshop.
 4. "Development of a 77GHz Gyrotron for LHD Experiments" by T. Kariya, Univ. Tsukuba, PRC.
A high power (1 MW/ several sec. and 0.3 MW/CW) 77 GHz gyrotron has been developed under collaboration between Univ. of Tsukuba and NIFS. In the presentation, he reported the design and obtained test results of the 1st and 2nd 77 GHz gyrotrons. He also mentioned the further prospect of the high performance gyrotrons in future.
 5. "An Advanced Millimeter Wave Reflectometer" by T. Tokuzawa, NIFS
Dr. Tokuzawa explained a diagnostic method of a millimeter wave reflectometer used in LHD experiments, for example an ultra-short pulsed radar reflectometer and a frequency hopping reflectometer. He also introduced a plan of a THz pulsed radar reflectometer.
- 1) T. Saito *et al.*, Proceedings of the Global Congress on Microwave Energy Applications, GCMEA 2008, MAJIC 1st, August 4-8, 2008, Otsu Japan, pp549-580.