

## §21. Technology and Application of High Power Micro-, Millimeter- and TeraHertz-Wave Sources – High Power Electron Tubes

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### i) Objectives

In LHD experiments, a Mega-Watt millimeter wave system (77 GHz and 154 GHz) is used for strong electron heating. In the diagnostic aspects, electron temperature profiles and temperature fluctuations are measured using electron cyclotron emissions from a plasma over a millimeter wave range. In these days, microwave, millimeter wave and Tera-Hertz wave oscillators and some components have been progressively developed and applied to plasma, material and medical sciences. Particularly, vacuum electron tubes realize high power and/or steady-state output, eg. tetrodes for ICRF heating, gyrotrons for ECRH.

The objective of this workshop is to promote the exchange of the state-of-the-art informations among the researchers of micro-, millimeter- & TeraHertz-waves for the improvement in each field and the development of combined research fields.

### ii) Activities in FY2012

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 micro-, millimeter- & TeraHertz-waves. Main themes in this fiscal year are as follows,

1. Present status of the research, development and manufacturing of micro-, millimeter- & TeraHertz-wave vacuum tubes using electron beams, e.g., klystrons and gyrotrons.
2. Application of high power micro-, millimeter- & TeraHertz-wave vacuum tubes to the research fields other than nuclear fusion.

We had a workshop in January 16th, 2013 under the keywords of “Technology and Application of High Power Micro-, Millimeter- and TeraHertz-Wave Sources - High Power Electron Tube”. The workshop mainly included two topical lectures and recent research reports by three collaborators.

The participants distributed over wide area related to the micro-, millimeter- & TeraHertz-wave technology and its application. About 21 members joined the workshop. The viewgraphs of each presentation were summarized and distributed in the CD-ROM for convenience.

### iii) Brief Summary of the Workshop

### **Presentations: Lectures**

1. “The Latest Status of High Power Klystron Development for Big-Science Projects”

by Dr. K. Hayashi, Toshiba Electron Tubes & Devices (TETD) Co, Ltd.

He introduced the latest high power klystrons which are manufactured and developed in TETD for the big-science projects. For example, 507MHz, 1.2MW, CW klystrons for the synchrotron orbit radiation facilities, S-band 100MW pulse klystrons, C-band 50MW pulse klystrons, and so forth. Especially, he explained the detailed design, fabrication and test results of two new klystrons, such as 324MHz/ 97MHz 3MW klystrons for J-PARK and a 5GHz, 500kW, CW klystron for lower-hybrid current drive in KSTER tokamak.

2. “Research and Development of micro- and millimeter-wave vacuum electron tubes in KEK”

by Dr. M. Yoshida, Accelerator Laboratory, KEK.

In KEK, they have been developing many kinds of high power klystrons for accelerators, such as 2.856GHz, 1.3GHz, 508MHz, 324MHz klystrons and so on. Recently, klystrons with higher efficiency are required. Besides, high power millimeter-wave sources are also required for particle acceleration by ultra-steep gradient of the electric field. In this aspect, they have been developed a millimeter-wave FEL and vacuum electron tubes. In these days, they are changing the research target to the power sources using strong Laser and high-density particle beams. He introduced the development of these devices, related technologies and their application in detail.

### **Presentations: Research Reports**

3. “Research of Bloch-wave Devices Intending Millimeter- and Submillimeter-Wave Oscillation”

by Dr. K. Yambe, University of Niigata.

4. “Research of an Electro-Optic Sampling of TeraHertz Waves using Cherenkov Phase Matching and Heterodyne Methods”

by Dr. M. Tani, Fukui University.

5. “Present Status of Gyrotron Development for ITER Procurement”

by Dr. K. Sakamoto, Japan Atomic Energy Agency.