

§2. Research on mm and Sub-mm Wave Technology and Applications

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1. 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, applied researches of the electromagnetic waves in this wavelength regime expand to many fields. In National Institute for Fusion Science, there are lots of millimeter wave devices such as gyrotrons, transmission lines and millimeter wave detectors for plasma experiments. The millimeter wave power is utilized for not only plasma heating, but also for electron temperature measurement through the electron cyclotron emission from the plasmas. Since the millimeter wave technology, which includes power sources, detectors and components, is still developing, it is important to catch up with the leading edge of such technology for the improvement of ECH and ECE system. 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 systems and development of combined research fields.

2. Activities in FY2006

The activity of this fiscal year was to research applications of millimeter and sub-millimeter wave technologies. Researchers on the different fields attended on the workshop under the keyword of "mm and sub-mm wave technologies"

Main subjects dealt with were

1. Millimeter wave technologies related with nuclear fusion research.
2. Power sources in the millimeter wave range.
3. Prospect of millimeter and sub-millimeter wave technologies in non-fusion fields.

Following the main subjects, as Terahertz technologies in special, there were three lectures. The viewgraphs of each lecture were summarized in the CD-ROM for convenience. Program and contents of the lectures are as follows.

(1) "Development and Applications of Terahertz Gyrotrons" by Dr. Toshitaka Idehara (University of Fukui)

He introduced development of gyrotrons over sub-Tera and Terahertz ranges and their applications to plasma diagnostics, structure analysis of proteins by DNP-NMR, sintering of ceramics and so on in Research center for Development of Far-Infrared Region, Univ. of Fukui. There are wide varieties of gyrotron specification according to the intended purposes.

(2) "Radiation of Terahertz Electromagnetic Waves Excited by Femto Second Lasers and Its Application to Spectroscopic Diagnostics" by Dr. Masahiko Tani (Institute of Laser Engineering, Osaka University).

About 20 years ago, electromagnetic(EM) wave radiation was observed from a photo-conductive switching device irradiated by a femto second Laser. Since then, researches of spectroscopic methods have made rapid progress in the Terahertz range, e.g. Terahertz Time Domain Spectroscopy; THz-TDS. He overviewed a lot of methods of EM wave generation excited by femto sec. Lasers and its applications to spectroscopic measurements, which were performed in their laboratory.

(3) "Development of Imaging Technologies by Using Millimeter and Sub-millimeter Waves for Astronomical Observation" by Dr. Hiroshi Matsuo (National Astronomical Observatory of Japan).

Recently detectors with higher sensitivity, wider viewing field and higher spatial resolution are required for astronomical observation in the millimeter and sub-millimeter wave (far infrared) range. It is essential to develop a two-dimensional detector array with high sensitivity and wide viewing field and interference technology with ultra-wide bandwidth. He presented the development of a imaging array equipped with a superconducting tunnel junction, which is fabricated under collaboration between NAOJ and RIKEN, and also introduced a methodology of an interferometric synthetic aperture radar which is proceeded under collaboration with Tohoku University. A good imaging performance will be expected with a combination of these two technologies.

Nearly twenty members joined the workshop. All of those are distributed over wide areas related to the millimeter wave technology. As for (1) the high power millimeter wave application to plasma heating, researchers in NIFS and Kyoto Univ. attended the workshop and discussed current and future technologies in detail. As for (2) the generators of high power micro- and millimeter waves and (3) millimeter wave detectors and technologies, researchers in Fukui Univ. Osaka Univ., Tohoku Univ. and NAOJ attended the workshop and exchanged informative issues.