

## §9. 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 (MM & SMM) wave range have been utilized for the plasma heating, current drive, plasma control and advanced plasma diagnostic methods in the nuclear fusion research. On the other hand, the applications of the electromagnetic waves in this frequency range are expanding to many other fields. The high power handling technologies, in particular, used in the fusion research will be more useful in the other research fields.

Applications of MM & SMM 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 the fusion systems and the advanced diagnostics of fusion plasmas.

The objective of this workshop is to encourage the exchange of the state-of-the art informations among the researchers of MM & SMM waves and microwave technologies, for the improvement in each field and the development of combined research fields.

**ii) Activities in FY2009** 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 MM & SMM waves.

First, we organized a symposium entitled "The collaboration between the developments and the applications in high power source in the Tera-Hz region", during the 26th annual meeting of the Japan Society of Plasma and Nuclear Fusion Research. The purposes of this symposium are to explore the new application of MM & SMM waves and to strengthen the collaboration between the researchers working in the related fields. Six specialists (Drs. T. Saito, M. Asakawa, K. Tanaka, T. Akiyama and S. Takayama) on the development and application of the MM & SMM waves, including the members of this collaboration group, presented their recent results and discussed about the direction and the way of collaboration between the plasma and fusion research and the other areas in the development and the applications of MM & SMM waves.

Second, we had another workshop on plasma heating and diagnostics in August 5th, 2009 under the keywords of "Expansion from millimeter waves to sub-millimeter/terahertz wave region and application of these waves". The workshop is organized by three top-

ical lectures and four reports as listed below. The participants distributed over wide area related to the millimeter wave technology. About 23 members joined the workshop. The viewgraphs of each presentations were summarized in the CD-ROM for convenience.

### Presentations:Lectures

1. "Polarimeter/Interferometer for Fusion Plasma using 57/48  $\mu$  laser" by Dr. T Akiyama, NIFS  
The electron density measurement by the interferometry and the internal magnetic field measurement by the polarimetry are the basic and important diagnostics for assessing and improving the performance of the fusion plasmas. Super-dense discharge in LHD or high density discharge in ITER require shorter wavelength of the order of 50  $\mu$ m than readily available region. The authors developed a laser using the CH<sub>3</sub>OD as a working gas oscillating at 57 and 48  $\mu$ m, simultaneously and related optical components. The measuring system and development status of the related component were discussed.
2. "Development of the Compact FEL in the Tera-Hz region utilizing Cherenkov Emission" by Dr. M. Asakawa, Kansai Univ.  
The authors are developing small Cherenkov FEL at Tera-Hz region, relatively simple in structure as compared with other sources. Further minimization of the system is tried by adopting field emitter array (FEA) as an electron beam source. The principle of the Cherenkov FEL and the simulation results and the recent results of the focusing of the electron beam from FEA were discussed.
3. "Basic Researches utilizing Tera-Hz Radiation " by Dr. K. Yamamoto, Univ. of Fukui,  
Recent Tera-Hz wave application examples are discussed. Those topics included the basic researches on the dynamics in the disordered condensed materials such as charge transfer complexes, ionic liquids and proteins as well as detection of explosive inside an envelope, diagnostic of polymer degradation.

### Presetations:Reports

1. "Fabrication of the Tera-Hz Waveguides and Trial for the Powerful Tera-Hz Source Development" by Dr. N. Sarukura, Osaka Univ.
2. "Free Electron Maser utilizing Advanced Bragg Mirror" by Dr. K. Kamada, Kanazawa Univ.
3. "ECCD Experiments in Heliotron-J", by Dr. K. Nagasaki, Kyoto Univ.
4. "Introduction of the High Power Long Pulse 77 GHz Gyrotrons in LHD", by Dr. H. Takahashi, NIFS