Sponsored by:
NASA Office of Aeronautics and Space Technology (OAST)
University Space Engineering Research Centers Program

Organized Jointly by:
NASA Center for Space Terahertz Technology, The University of Michigan
Center for Space Microelectronics Technology, Jet Propulsion Laboratory

SYMPOSIUM PROCEEDINGS

March 5-6, 1990
Lee Iacocca Lecture Hall, Dow Building
The University of Michigan
Ann Arbor, Michigan
Proceedings of the
FIRST INTERNATIONAL SYMPOSIUM ON
SPACE TERAHERTZ TECHNOLOGY

March 5-6, 1990
Lee Iacocca Lecture Hall, Dow Building
The University of Michigan
Ann Arbor, Michigan
Preface

The First International Symposium on Space Terahertz Technology featured papers from academia, government agencies, and industry, summarizing research results relevant to the generation, detection and use of the terahertz spectral region for space astronomy, remote sensing studies of the earth's upper atmosphere and other applications. The presentations covered a wide range of subjects including solid-state oscillators, mixers, harmonic multipliers, antennas, networks, receivers and measurement techniques. Although the discussions focused on the 0.1-1 THz region (3000-300μm), some of the papers examined higher frequencies as well. The program was international in scope, featuring noted researchers from the U.S., Japan, and several European countries.

The Symposium was sponsored by NASA's Office of Aeronautics and Space Technology (OAST) and was organized jointly by The University of Michigan's NASA Center for Space Terahertz Technology and JPL's Center for space Microelectronics Technology. It is our hope that this first symposium will set the stage for future symposia on space terahertz technology to serve as the meeting ground for scientists and engineers interested in this field.

Fawwaz T. Ulaby
Carl A. Kukkonen
Organizing Committee

Fawwaz T. Ulaby, The University of Michigan
Carl A. Kukkonen, Jet Propulsion Laboratory
George I Haddad, The University of Michigan
Gabriel Rebeiz, The University of Michigan
Margaret A. Frerking, Jet Propulsion Laboratory
Barbara Wilson, Jet Propulsion Laboratory
Valerie Franklin, The University of Michigan
Contents

Opening Session

Chair: Fawwaz Ulaby

Overview of The University of Michigan Space Terahertz Program........................................5
F. T. Ulaby

Overview of NASA's Terahertz Technology Program...............................................................33
M. Sokoloski, C. A. Kukkonen

Astrotech 21: Terahertz Technology for Space Astronomy in the 21st Century.......................69
J. A. Cutts

Session 1: Oscillators

Chair: Erik Kollberg

Submillimeter-wave Resonant-tunneling Oscillators...............................................................74
E. R. Brown

Potential and Limitations of Resonant Tunneling Diodes......................................................84
C. Kidner, I. Mehdi, J. R. East, G. I. Haddad

Tunnel Transit-time (TUNNETT) Devices for Terahertz Sources..........................................104
G. I. Haddad, J. R. East

Watt-level Quasi-optical Monolithic Frequency Multiplier Development............................126
R. J. Hwu; N. C. Luhmann, Jr.; L. Sjogren; X. H. Quin; W. Wu; D. B. Rutledge;
B. Hancock; J. Maserjian; U. Lieneweg; W. Lam; C. Jou

Submicrometer Devices and Monolithic Functions Using InAlAs/InGaAs Heterostructures........150
G. I. Ng, Y. Kwon, D. Pavlidis

Session 2: Antennas & Circuits

Chair: Michael Stroscio

Aperture Efficiency of Integrated-circuit Horn Antennas.....................................................169
Y. Guo, K. Lee, P. Stimson, K. Potter, D. Rutledge

Integrated Tapered Slot Antenna Arrays and Devices............................................................176
K. S. Yngvesson

Theoretical Analysis of a Dipole-fed Horn Antenna...............................................................187
G. Eleftheriades, W. Ali-Ahmad, L. P. B. Katehi, G. M. Rebeiz

Twin-slot Multi-layer Substrate-supported Antennas and Detectors for Terahertz Imaging......1201
S. M. Wentworth, R. L. Rogers, J. G. Heston, D. P. Neikirk

A Wideband Monolithic Submillimeter-wave Quasi-optical Power Meter............................214
C. C. Ling, G. M. Rebeiz

A Submillimeter-wave Heterodyne Array Receiver Using a Dielectric-filled.......................218
Parabola: Concept and Design
P. H. Siegel

Millimeter and Submillimeter Studies of Planar Antennas...................................................235
H. van de Stadt, Th. de Gaauw, A. Skalare, R. A. Panhuyzen, R. Zwiggelaar
Session 3: Mixers & Multipliers  

Chair: Carl Kukkonen

GaAs Schottky Barrier Diodes for Space-based Applications at Submillimeter Wavelengths
T. W. Crowe, W. C. B. Peatman, W. L. Bishop

Recent Results on: Surface-channel Schottky, InGaAs Schottky, and Nb Based SIS Mixer Element Research
R. J. Mattauch, W. L. Bishop, A. W. Lichtenberger

Capability of Schottky Diode Multipliers as Local Oscillators at 1 THz
A. Räisänen, M. Sironen

Planar Doped Barrier Devices for Subharmonic Mixers
J. R. East, T. Lee, G. I. Haddad

Quantum Well Multipliers: Triplers and Quintuplers
M. A. Frerking

Session 4: Receiver Systems  

Chair: Anthony Kerr

SIS Receivers for Submillimeter-wave Astronomy
T. G. Phillips, T. H. Büttgenbach, B. N. Ellison

Some Recent Developments in the Design of SIS Mixers
A. R. Kerr, S. K. Pan

Multi-element Quasi-optical Oscillator Arrays for Terahertz Region
M. Nakayama, M. Hieda, T. Tanaka, K. Mizuno

Quantum Well and Quantum Barrier Diodes for Generating Submillimeter Wave Power
H. Grönqvist, E. Kollberg, A. Rydberg

Low Noise 500- to 700-GHz Receivers Using Single-diode Harmonic Mixers
N. R. Erickson

Development of a 600- to 700-GHz SIS Receiver

Session 5: Applications  

Chair: Sam Gulkis

Submillimeter Astronomy in France
P. Encrenaz

Submillimeter Wavelength Astronomy Missions for the 1990s
S. Gulkis

Submillimeter Wave Astronomy Satellite
P. F. Goldsmith

Submillimeter Remote Sensing of Stratospheric Gases
J. W. Waters

Atmospheric Remote Sensing in the Terahertz Region
P. B. Hays, H. E. Snell