

# **PROCEEDINGS**

**Eleventh International Symposium on  
Space Terahertz Technology**

**May 1-3, 2000**

**On the Grounds of  
The University of Michigan  
Ann Arbor, Michigan**



**Organized by: The University of Michigan, Solid-State Electronics Laboratory**

## Preface

The 11<sup>th</sup> International Symposium on Space Terahertz Technology was held on the campus of The University of Michigan on May 1-3, 2000. The Symposium was attended by 120 scientists and engineers from around the world. Nearly 70 papers were presented in 10 regular sessions, a poster session and an opening session with 2 invited papers. The papers covered the wide range of topics included in THz technology. Superconducting technologies such as SIS and HBT mixers, semiconductor based mixers and multipliers, semiconductor sources and several other THz technologies were covered. The two invited papers in the opening session discussed potential future uses of this technology for DARPA and ARO needs.

I would like to thank Ms. Catharine June for handling the infinite number of tasks involved in this conference, including running the Web page, organizing the local arrangements and putting together the Symposium Digest.

The 2001 conference will be held at

Humphrey's Half Moon Inn  
Shelter Island  
San Diego, California  
February 14-16, 2001

The abstract due date is December 1, 2000. This early date will allow an overlap with the FIRST science workshop to be held during the same week in San Diego. Additional conference information is available from

Dr. Imran Mehdi  
Mail Stop 168-314  
Jet Propulsion Laboratory  
Pasadena, CA. 91109-8001  
Phone 818-354-2001  
Fax 818-393-4683  
Email: [imran@merlin.jpl.nasa.gov](mailto:imran@merlin.jpl.nasa.gov)

I am looking forward to seeing all of you in San Diego.

Jack East  
Chair, 11th Symposium on Space Terahertz Technology

# 11TH INTERNATIONAL SYMPOSIUM ON SPACE TERAHERTZ TECHNOLOGY



**Monday - Wednesday, May 1-3, 2000**  
**University of Michigan**  
**Ann Arbor, Michigan**

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## DAY 1 - MONDAY, MAY 1

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### Opening Session

**Chair: Jack East**

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| Introduction and Welcome                                                 | Fawwaz Ulaby      | U. Michigan |    |
| Next Generation of Terahertz Sources and Detectors                       | Edgar J. Martinez | DARPA       | 1  |
| Terahertz Electronics Research for Defense: Novel Technology and Science | Dwight Woolard    | ARO         | 22 |

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### Session 1: HEB 1

**Chair: Eyal Gerecht**

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| Frequency Dependence Noise Temperature of the Lattice Cooled Hot-Electron Terahertz Mixer                                 | A. D. Semenov, H.-W. Huebers, J. Schubert, G.N. Gol'tsman, A.I. Elantiev, B. M. Voronov, E. M. Gershenzon         | State Ped. U., Moscow<br>DLR, Germany                                      | 39 |
| Successful Operation of a 1 THz NbN Hot-Electron Bolometer Receiver                                                       | C.-Y. E. Tong, J. Kawamura, T. R. Hunter, D. C. Papa, R. Blundell, M. Smith, F. Patt, G. Gol'tsman, E. Gershenzon | Harvard<br>Caltech<br>Submillimeter Telescope Obs.<br>Moscow State Ped. U. | 49 |
| Microstripline-Coupled Quasi-Optical Niobium Hot Electron Bolometer Mixers around 2.5 THz                                 | W. F. M. Ganzevles, J. R. Gao, P. Yagoubov, T. M. Klapwijk, P. A. J. de Korte                                     | DIMES<br>SRON                                                              | 60 |
| Direct and Heterodyne Response of Quasi Optical Nb Hot-Electron Bolometer Mixers Designed for 2.5 THz Radiation Detection | W. F. M. Ganzevles, J.R. Gao, W.M. Laauwen, G. de Lange, T. M. Klapwijk, P. A. J. de Korte                        | DIMES<br>SRON                                                              | 69 |
| Aluminum Sub-Micron Superconducting Hot-Electron Bolometer Mixer                                                          | I. Siddiqi, A. Verevkin, D. E. Prober, A. Skalare, B.S. Karasik, W.R. McGrath, P. Echterbach, H.G. LeDuc          | Yale<br>JPL                                                                | 82 |

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| A 350 GHz SIS Imaging Module for the JCMT Heterodyne Array Receiver Programme (HARP)   | J. Leech, S. Withington, G. Yassin, H. Smith, B.D. Jackson, J.R. Gao, T.M. Klapwijk                                           | U. Cambridge<br>SRON<br>DIMES       | 105 |
| A Low Noise NbTiN-based 850 GHz SIS Receiver for the Caltech Submillimeter Observatory | J. W. Kooi, J. Kawamura, J. Chen, G. Chattopadhyay, J.R. Pardo, J. Zmuidzinas, T.G. Phillips, B. Bumble, J. Stern, H.G. LeDuc | Caltech<br>JPL<br>Tohoku University | 116 |
| Quasi-Optical Terahertz SIS Mixer                                                      | A. M. Baryshev, B. D. Jackson, G. de Lange, S. V. Shitov, N. Iosad, J. R. Gao, T. Klapwijk                                    | SRON<br>IREE RAS, Russia<br>DIMES   | 129 |

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| The Oxide Barrier Varactor                                                                                                             | T. W. Crowe, Y. Duan                                            | UVa                                     | 153 |
| Power Generation with Fundamental and Second-Harmonic Mode InP Gunn Oscillators - Performance Above 200 GHz and Upper Frequency Limits | R. Kamoua, H. Eisele                                            | SUNY, Stony Brook<br>U. Michigan        | 155 |
| GaN-based NDR Devices for THz Generation                                                                                               | E. Alekseev, A. Eisenbach, D. Pavlidis, S.M. Hubbard, W. Sutton | U. Michigan                             | 162 |
| Broadband Fixed-Tuned Subharmonic Receivers to 640 GHz                                                                                 | J. Hesler                                                       | UVa                                     | 172 |
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| Superconducting Transition Edge Sensor Bolometer Arrays for Submillimeter Astronomy | D.J. Benford, C. A. Allen, A. S. Kuttyrev, S.H. Moseley, R.A. Shafer, J. A. Chervenak, E. N. Grossman, K. D. Irwin, J. M. Martinis, C. D. Reintsema | NASA<br>NIST | 187 |
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| Development of Focal Plane Arrays Utilizing NbN Hot Electron Bolometric Mixers for the THz Regime              | E. Gerecht, C. F. Musante, Y. Zhuang, M. Ji, K. S. Yngvesson, T. Goyette, J. Waldman                       | U. Mass.                                                | 209 |
| IF Bandwidth of Phonon Cooled HEB Mixers Made from NbN films on MgO Substrates                                 | S. Cherednichenko, M. Kroug, P. Yagoubov, H. Merkel, E. Kollberg, K.S. Yngvesson, B. Voronov, G. Gol'tsman | Chalmers U.<br>U. Mass.<br>Moscow State Ped. U.         | 219 |
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| A Single-Chip Balanced SIS Mixer for 200-300 GHz                                                               | A. R. Kerr, S.-K. Pan, A.W. Lichtenberger, N. Horner, J. E. Effland, K. Crady                              | NRAO<br>UVa                                             | 251 |
| Performance of Sub-Harmonic Mixing With an SIS Junction                                                        | S.-C. Shi, W.-L. Shan, T. Noguchi, K.-C. Xiao                                                              | Purple Mountain<br>Observatory, China<br>NRO, Nagoya U. | 260 |
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| A New Laser Micromachining System for the Fabrication of THz Waveguide and Quasi-Optical Components            | C. Walker, C. D. D'Aubigny, C. Groppi, J. Papapolymerou, G. Chin, A. Lichtenberger                         | U. Arizona<br>NASA<br>UVa                               | 275 |
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| 200 and 400 GHz Schottky Diode Multipliers Fabricated with Integrated Air-Dielectric "Substrateless" Circuitry | E. Schlecht, J. Bruston, A. Maestrini, S. Martin, D. Pukala, R. Tsang, A. Fung, R. P. Smith, I Mehdi       | JPL<br>Cree, Inc., NC                                   | 287 |

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Chair: Tom Crowe

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| Narrow-Band Terahertz Waveform Generation in Periodically-Poled Lithium Niobate                                                   | T. Meade, Y.-S. Lee, V. Perlin, H. Winful, T. B. Norris, A. Galvanauskas                                                                                        | U. Michigan<br>IMRA America, MI                                                                                       | 326 |
| Resonant Tunneling THz Oscillator at Fixed Bias Voltages                                                                          | P. Zhao, H. L. Cui, D. Woolard                                                                                                                                  | Stevens Inst. Tech., NJ<br>ARO                                                                                        | 336 |
| SuperMix Now Available                                                                                                            | F. Rice, J. Ward, J. Zmuidzinis, G. Chattopadhyay                                                                                                               | Caltech                                                                                                               | 341 |
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| Modelling Few-Moded Horns for Far-IR Space Applications                                                                           | R. Colgan, J. A. Murphy, B. Maffei, C. O'Sullivan, R. Wylde, P. Ade                                                                                             | National U., Ireland<br>Queen Mary and Westfield College, UK                                                          | 368 |
| Submillimeter-Wave Spectral Response of Twin-Slot Antennas Coupled to Hot Electron Bolometers                                     | R.A. Wyss, A. Neto, W.R. McGrath, B. Bumble, H. LeDuc                                                                                                           | JPL                                                                                                                   | 379 |
| Tunable Antenna-Coupled Intersubband Terahertz (TACIT) Detectors for Operation Above 4K                                           | C. L. Cates, J. B. Williams, M. S. Sherwin, K. D. Maranowski, A. C. Gossard                                                                                     | UC - Santa Barbara                                                                                                    | 389 |
| SIS Receivers for the 1.2 THz Frequencies Using NbTiN/AlN/Nb Junctions                                                            | A. Karpov, J. Zmuidnizis, F. Rice, D. Miller, J.A. Stern, H.G. LeDuc                                                                                            | Caltech<br>JPL                                                                                                        | 397 |
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| An Efficient Technique for the Optimization of Submillimeter-wave Schottky-diode Harmonic Multipliers | C.-C. Lee, B. Gelmont, D. Woolard                            | UVa<br>ARO                                              | 433 |
| Developments of the 810-GHz SIS Receiver with Nb-based Junctions                                      | H. Maezawa, T. Noguchi, S.-C. Shi, Y. Sekimoto, S. Yamamoto  | U. Tokyo<br>Nobeyama Radio Obs.<br>Purple Mountain Obs. | 444 |
| Bias Dependence of the Thermal Time Constant in Nb Superconducting Diffusion-Cooled HEB Mixers        | D. Wilms Floet, J. R. Gao, T. M. Klapwijk, P. A. J. de Korte | DIMES<br>SRON                                           | 455 |
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### DAY 3 - WEDNESDAY, MAY 3

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#### Session 8: HEB 3

Chair: Eric Kollberg

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| A Distributed Device Model for Phonon-Cooled HEB Mixers Predicting IV Characteristics, Gain, Noise and IF Bandwidth | P. Khosropanah, H. Merkel, S. Yngvesson, A. Adam, S. Cherednichenko, E. Kollberg                           | Chalmers U.<br>U. Mass.<br>Supélec  | 474 |
| Properties of Nb Thin Films and their Application for Diffusion-Cooled Hot-Electron Bolometer                       | M. Frommberger, F. Mattiocco, P. Sabon, M. Schicke, K. F. Schuster, O. Laborde                             | IRAM, France<br>CRTBT, France       | 489 |
| Diffusion-Cooled Aluminum Hot-Electron Bolometer Mixers at Submillimeter Wavelengths                                | A. Skalare, W. R. McGrath, P. M. Echternach, H. G. LeDuc, I. Siddiqi, A. Verevkin, D.E. Prober             | JPL<br>Yale U.                      | 501 |
| Noise and Mixing in Aluminum Based Sub-Micron Hot-Electron Bolometers                                               | A. Verevkin, I. Siddiqi, D. E. Prober, A. Skalare, B.S. Karasik, W.R. McGrath, P.M. Echternach, H.G. LeDuc | Yale U.<br>JPL                      | 513 |
| Hot-Electron Detectors: Toward Record Sensitivity Via Disorder-Suppressed Electron-Phonon Coupling                  | M. E. Gershenson, D. Gong, T. Sato, B. S. Karasik, W. R. McGrath, A. V. Sergeev                            | Rutgers U.<br>JPL<br>Wayne State U. | 514 |

#### Session 9: HIGH TC

Chair: Jeffrey Hesler

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| Systematic Study of IF Bandwidth in HTS Hot-Electron Bolometer Mixers                       | O. Harnack, K. Ilin, M. Siegel, B. S. Karasik, W. R. McGrath, G. de Lange                                                                        | IfSI, Germany<br>JPL<br>SRON                                                                     | 525 |
| YBa <sub>2</sub> Cu <sub>3</sub> O <sub>7-δ</sub> Hot-Electron Bolometer Mixer at 0.6 THz   | S. Cherednichenko, F. Rönning, G. Gol'tsman, E. Kollberg, D. Winkler                                                                             | Chalmers U.<br>Moscow State Pedagogical U., Russia                                               | 526 |
| Externally Phase Locked Submm-Wave Flux Flow Oscillator for Integrated Receiver             | V. P. Koshelets, A. B. Ermakov, S. V. Shitov, P. N. Dmitriev, L. V. Filippenko, A. M. Baryshev, W. Luinge, J. Mygind, V. L. Vaks, D. G. Pavel'ev | IREE, Russia<br>SRON<br>Tech. U., Denmark<br>IPM, RAS, Russia<br>Nizhny Novgorod State U. Russia | 532 |
| Evaluation of High-Tc Elements in Submm-Mixers                                              | D. Diehl, R. Zimmerman, J. Scherbel, M. Darula, O. Harnack, M. Siegel                                                                            | RPG Radiometer-physics, Germany<br>IfSIF, Germany                                                | 542 |
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| High Q InP-based Varactor Diodes                                                            | T. David, S. Arscott, P. Mounaix, X. Mélique, F. Mollot, O. Vanbésien, M. Chaubet, D. Lippens                                                    | U. of Science and Technology, U. de Lille<br>Centre Nat. d'Etudes Spatiales, France              | 552 |
| Heterostructure Barrier Mixers for Terahertz Applications                                   | F. Podevin, P. Mounaix, O. Vanbésien, M. Chaubet, D. Lippens                                                                                     | U. of Science and Technology, U. de Lille<br>Centre Nat. d'Etudes Spatiales, France              | 561 |
| A 4-8 GHz Quasi-MMIC IF Amplifier for a 690 GHz SIS Receiver                                | J. Ward, D. Miller, J. Zmuidzinas, P. O'Brien, H. G. LeDuc, R. Bicknell-Tassius                                                                  | Caltech<br>JPL                                                                                   | 570 |
| Nonlinear Transport in Ballistic Semiconductor Diodes with Negative Effective Mass Carriers | B.R. Perkins, J. Liu, A. Zaslavsky, Z.S. Gribnikov, V.V. Mitin, E.P. De Poortere, M. Shayegan                                                    | Brown U.<br>Wayne State U.<br>Princeton                                                          | 582 |
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| Design and Analysis of a Hybrid Feed Antenna for a Flux-Flow Oscillator Integrated 460 GHz SIS Receiver | M.-H. Chung, M. Salez                                                        | DEMIRM, Paris                        | 626 |