

PROCEEDINGS OF SPIE

*2021 International Conference on Optical
Instruments and Technology*

IRMMW-THz Technologies and Applications

Cunlin Zhang
Xi-Cheng Zhang
Zhiming Huang
Libin Tang
Ze-Ren Li
Xin Tang
Editors

8–10 April 2022
Online Only, China

Sponsored by
CIS – China Instrument and Control Society (China)

Cosponsored and Published by
SPIE

Volume 12284

Proceedings of SPIE 0277-786X, V. 12284

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

2021 International Conference on Optical Instruments and Technology: IRMMW-THz Technologies and Applications,
edited by Cunlin Zhang, Xi-Cheng Zhang, Zhiming Huang, Libin Tang, Ze-Ren Li, Xin Tang, Proc. of SPIE
Vol. 12284, 1228401 · © 2022 SPIE · 0277-786X · doi: 10.1117/12.2641678

Proc. of SPIE Vol. 12284 1228401-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:
Author(s), "Title of Paper," in *2021 International Conference on Optical Instruments and Technology: IRMMW-THz Technologies and Its Applications*, edited by Cunlin Zhang, Xi-Cheng Zhang, Zhiming Huang, Libin Tang, Ze-Ren Li, Xin Tang, Proc. of SPIE 12284, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510655737
ISBN: 9781510655744 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

SPIE.org

Copyright © 2022 Society of Photo-Optical Instrumentation Engineers (SPIE).

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

v	<i>Symposium Committee</i>
vii	<i>Conference Committee</i>
ix	<i>Introduction</i>
xi	<i>Cooperating Organizations</i>

IRMMW-THZ TECHNOLOGIES AND APPLICATIONS I

12284 02	Experimental comparison of terahertz time-domain spectroscopy with double-probe methods in atmospheric plasma density diagnosis [12284-6]
----------	--

IRMMW-THZ TECHNOLOGIES AND APPLICATIONS II

12284 03	Calibration of terahertz time-domain spectrometers and terahertz radiometry (Invited Paper) [12284-22]
12284 04	A metamaterial terahertz modulator based on negative differential conductance effect [12284-8]
12284 05	Preparation and photoelectric properties of SnTe nanofilm [12284-27]

POSTER SESSION

12284 06	Optical constants of lactose pumped by strong terahertz waves [12284-1]
12284 07	Design and research of high sensitivity metamaterial sensor [12284-7]
12284 08	Research on terahertz near-field probe based on surface plasmon polaritons [12284-13]
12284 09	Joint waveforms generation for wireless communication and sensing at MMW-band based on heterodyne detection [12284-15]
12284 0A	Application of BDS timing clock in high-speed THz-TDS [12284-16]
12284 0B	A study on the quantitative relationship between the gray value of active terahertz images and transmission thickness [12284-18]

- 12284 0C **Research on empirical tight-binding method calculation energy band of InAs/InAsSb superlattice** [12284-20]
- 12284 0D **Impact of precipitates in CdZnTe substrates on defects of HgCdTe film grown by molecular beam epitaxy** [12284-23]
- 12284 0E **Size-controlled synthesis SnSe₂ QDs and its optical properties** [12284-28]
- 12284 0F **Research progress in the preparation of black silicon and its photoelectric detection** [12284-29]
- 12284 0G **Research progress in the preparation of quantum dot films for optoelectronic devices** [12284-30]
- 12284 0H **Research progress in ultraviolet focal plane detectors** [12284-31]

Symposium Committee

Symposium Chairs

Zheng You, CIS (China), Tsinghua University (China)
David Andrews, University of East Anglia (United Kingdom)

Symposium Co-chairs

Tianchu Li, National Institute of Metrology, China (China)
Songlin Zhuang, University of Shanghai for Science and Technology (China)
Liwei Zhou, Beijing Institute of Technology (China)
Shenghua Ye, Tianjin University (China)
Yimo Zhang, Tianjin University (China)
Guangjun Zhang, Southeast University (China)
Min Gu, University of Shanghai for Science and Technology (China)
Xiangang Luo, Institute of Optics and Electronics, CAS (China)
Jianjun Deng, China Academy of Engineering Physics (China)
Fengyi Jiang, Nanchang University (China)

Technical Program Chairs

Guofan Jin, Tsinghua University (China)
Tianchu Li, National Institute of Metrology (China)

Technical Program Co-chairs

Jinxue Wang, SPIE
Tiegen Liu, Tianjin University (China)

Local Organizing Committee Chairs

Youhua Wu, China Instrument and Control Society (China)
Tong Zhang, China Instrument and Control Society (China)

Local Organizing Committee Co-chairs

Qun Hao, Beijing Institute of Technology (China)
Guoqiang Ni, Beijing Institute of Technology (China)

General Secretaries

Tong Zhang, China Instrument and Control Society (China)
Li Zhang, China Instrument and Control Society (China)

Vice General Secretaries

Liquan Dong, Beijing Institute of Technology (China)

Yuejin Zhao, Beijing Institute of Technology (China)

Qican Zhang, Sichuan University (China)

Yu-nan Sun, Beijing Institute of Technology (China)

Local Organizing Committee

Xuping Zhang, Nanjing University (China)

Shangzhong Jin, China Jiliang University (China)

Liangcai Cao, Tsinghua University (China)

Yongtian Wang, Beijing Institute of Technology (China)

Chunqing Gao, Beijing Institute of Technology (China)

Jian Chen, Nanjing University of Posts and Telecommunications (China)

Shilong Pan, Nanjing University of Aeronautics and Astronautics (China)

Guohai Situ, Shanghai Institute of Optics and Fine Mechanics, CAS
(China)

Jigui Zhu, Tianjin University (China)

Baojun Li, Jinan University (China)

Cunlin Zhang, Capital Normal University (China)

Zeren Li, Shenzhen Technology University (China)

Libo Yuan, Guilin University of Electronic Technology (China)

Yongcai Guo, Chongqing University (China)

Tian Lan, Beijing Institute of Technology (China)

Cuiling Li, Beijing Institute of Technology (China)

Conference Committee

Conference Chairs

Cunlin Zhang, Capital Normal University (China)
Xi-Cheng Zhang, The Institute of Optics, University of Rochester
(United States)
Zhiming Huang, The Shanghai Institute of Technical Physics of the
Chinese Academy of Sciences (China)
Libin Tang, Kunming Institute of Physics (China)
Zeren Li, China Academy of Engineering Physics (China)
Xin Tang, Beijing Institute of Technology (China)

Conference Program Committee

Peter A. R. Ade, Cardiff University (United Kingdom)
Jun-Cheng Cao, Shanghai Institute of Microsystem and Information
Technology (China)
Hou-Tong Chen, The Center for Integrated Nanotechnologies
(United States)
Jian Chen, Nanjing University (China)
Jianming Dai, University of Rochester (United States)
Jiaguang Han, Tianjin University (China)
Zhi Hong, China Jiliang University (China)
Biaobing Jin, Nanjing University (China)
Weiqi Jin, Beijing Institute of Technology (China)
Yuejin Zhao, Beijing Institute of Technology (China)
Sheng-Cai Shi, Purple Mountain Observatory, Chinese Academy of
Sciences (China)
Fei-jun Song, China Daheng Group, Inc. (China)
Jianmin Yuan, National University of Defense Technology (China)
Chao Zhang, University of Wollongong (Australia)
Weili Zhang, Oklahoma State University (United States)
Yan Zhang, Capital Normal University (China)
Zhuoyong Zhang, Capital Normal University (China)
Kun Zhao, China University of Petroleum (China)
YiMing Zhu, University of Shanghai for Science and Technology (China)
Wenxin Liu, Institute of Electronics, CAS (China)

Conference Secretary

Zhenwei Zhang, Capital Normal University (China)

Conference Review Committee

Peter A. R. Ade, Cardiff University (United Kingdom)
Juncheng Cao, Shanghai Institute of Microsystem and Information
Technology, Chinese Academy of Sciences (China)
Hou-Tong Chen, Los Alamos National Laboratory (United States)
Jian Chen, Nanjing University (China)
Jianming Dai, Tianjin University (China)
Jiaguang Han, Center for Terahertz Waves of Tianjin University (China)
Zhi Hong, China Jiliang University (China)
Biaobing Jin, Nanjing University (China)
Weiqi Jin, Beijing Institute of Technology (China)
Sheng-Cai Shi, Purple Mountain Observatory, Chinese Academy of
Sciences (China)
Fei-jun Song, Daheng New Epoch Technology, Inc. (China)
Chao Zhang, University of Wollongong (Australia)
Weili Zhang, Oklahoma State University (China)
Yan Zhang, Capital Normal University (China)
Zhuoyong Zhang, Capital Normal University (China)
Yuejin Zhao, Beijing Institute of Technology (China)
Kun Zhao, China University of Petroleum (China)
Yiming Zhu, University of Shanghai for Science and Technology (China)

Session Chairs

- 1 IRMMW-THz Systems, Methods and Applications
Lu Rong, Beijing University of Technology (China)
Jinhai Sun, Science and Technology on EM Scattering Laboratory (China)
- 2 IRMMW-THz Sources and Detection
Yong Du, China Jiliang University (China)
Yuan Ren, Purple Mountain Observatory, Chinese Academy of Sciences
(China)
- 3 IRMMW-THz Methods and Applications
Yuqing Deng, National Institute of Metrology (China)
Libin Tang, Kunming Institute of Physics (China)

Introduction

With the mutually integration of IRMMW-THz technologies and applications, they have been mutually promoted and developed rapidly. Terahertz science and technology is not only due to it has not been fully explored, but due to its promising applications in spectroscopy, imaging, communications and nondestructive testing and so on. The tremendous demand has dramatically accelerated the research and development on the smaller terahertz emitter with high-power, the uncooled terahertz detector with high sensitivity, the portable and robust devices and systems with high speed. In recent years, many reliable new signal sources, detectors, functional devices and systems continue to emerge. Terahertz technology already plays a crucial role in aerospace, biological medicine, safety inspection, nondestructive testing, cultural relic's protection and next generation wireless communication.

At the same time, the research and development of small power terahertz radiation source, high sensitivity uncooled THz detector, a portable high speed portable equipment and system is still the key bottlenecks in technology. We are glad to see this subject attracting an increasing amount of attention and interests. Joint effort has been made by academia and industry combined to promote both terahertz science and technology development.

In this regard, IRMMW-THz Technologies and Applications of OIT2021 was organized. The conference accepted over 35 papers from different countries and areas of the world, which are focused on the novel device, system and application of IRMMW-THz science and technology, and crossed many research disciplines including plasma, metamaterials, testing and calibration, sensors, imaging and biomedical technology.

We also invited renowned scholars to present their cutting-edge, covering fundamental science such as, "Joint terahertz (THz) communications and sensing: future applications and key technology", and "Graphene based terahertz sensing scheme for cancer biomarker measurement in liquid environment".

Cunlin Zhang
Xi-Cheng Zhang
Zhiming Huang
Libin Tang
Ze-Ren Li
Xin Tang

Cooperating Organizations

Opto-Electronic Mechanic Technology and System Integration Chapter, CIS (China)
Committee on Optoelectronic Technology, COS (China)
Committee on Optics, China Ordnance Society (China)
Optical Instrument Chapter, CIS (China)
Beijing Institute of Technology (China)
Tianjin University (China)
Tsinghua University (China)
Peking University (China)
Nanjing University (China)
Zhejiang University (China)
Sichuan University (China)
Nankai University (China)
Capital Normal University (China)
Beijing University of Posts and Telecommunications (China)
Beihang University (China)
Chongqing University (China)
University of Shanghai for Science and Technology (China)
Instrument Society of America (United States)
Institute of Measurement and Control (United Kingdom)
Hong Kong Institution of Engineers (Hong Kong, China)
The Society of Measurement and Control (Japan)

