

Preface to the special issue on *Terahertz Wave Science, Technology, and Application*

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I am delighted to introduce the first special issue on *Terahertz (THz) Wave Science, Technology, and Application*. This issue contains five review and research papers, all written by former Ph.D students, Dr. Xiaofei Lu, Dr. Jingle Liu, Dr. Benjamin Clough, Dr. I-Chen Ho, and Dr. Yuting W. Chen, at the Center of THz Research, Rensselaer Polytechnic Institute. These gifted scientists and engineers are among the most brilliant students that have graduated in the THz community in the past four years. This issue covers research frontiers from THz antireflection silicon structure (Dr. Chen), remote sensing (Dr. Liu), and THz wave air photonics (Dr. Lu) to nonlinear THz wave-matter interaction (Dr. Ho), and THz enhanced acoustics (Dr. Clough).

THz radiation, which is electromagnetic radiation in a frequency interval from 0.3 to 10 THz (1 mm–30 μ m wavelength), is the next frontier in science and technology. This band occupies a large portion of the electromagnetic spectrum between the infrared and microwave bands. Basic research, new initiatives, and developments in advanced sensing and imaging technology, with regards to the THz band, remain largely unexplored compared to the relatively well-developed science and technology in the microwave and optical frequencies.

Historically, THz technologies were used mainly within the astronomy community for studying the background of cosmic far-infrared radiation, and by the laser-fusion community for the diagnostics of plasmas. Since the first demonstration of THz wave time-domain spectroscopy in the late 1980's, there have been a series of significant advances (particularly in recent years). More intense THz sources and higher sensitivity detectors are providing new opportunities for understanding the basic science in the THz frequency range.

As developments move forward, THz science will not only have an impact on material characterization and identification. It will also have potential applications in the fields of communications, imaging, medical diagnosis, health monitoring in environmental, chemical, and biological sensing, as well as security and quality control applications. Twenty-first century research in the THz band is one of the most promising areas of study for transformational advances in imaging and other interdisciplinary fields.

The THz frequency range is the last segment of the electromagnetic spectrum to be conquered. Far from being fully explored, it offers great opportunities in science, innovation, new technology and applied fields.

I thank many colleagues and friends for their guidance, support, and friendship. Special thanks to Dr. David Auston, Dr. Chi Lee, Dr. Dan Grischowsky, Dr. Dan Mittleman, Dr. Peter Siegel, Dr. Qing Hu, Dr. Keith Nelson, Dr. Charles Schmuttenmaer, Dr. Peter Jepsen, Dr. Paul Planken, Dr. Kiyomi Sakai, Dr. Cunlin Zhang, Dr. Jianquan Yao, Dr. Jinsong Liu, Dr. Gun-Sik Park, and Dr. Alexander Shkurinov.

I would like to thank those former students who have graduated from my THz group at Rensselaer: Ms. Yahong Jin, Ph.D, 1994; Mr. Xinfu Ma, Ph.D, 1995; Mr. Greg Wagoner, Ph.D, 1997; Mr. Qi Wu, Ph.D, 1997; Ms. Jennifer Riordan, Ph.D, 1998; Mr. Ming Li, Ph.D, 2000; Mr. Pengyu Han, Ph.D, 2000; Mr. F. G. Sun, Ph.D, 2001; Mr. Qin Chen, Ph.D, 2001; Mr. Kwang-Su Lee, Ph.D, 2002; Mr. Shaohong Wang, Ph.D, 2003; Ms. Fatemah M. Al-Douseri, Ph.D, 2005; Mr. Kai Liu, Ph.D, 2005; Mr. Haibo Liu, Ph.D, 2006; Mr. Tao Yuan, Ph.D, 2006; Ms. Hua Zhong, Ph.D, 2006; Mr. Xu Xie, Ph.D, 2007; Mr. Brian Schulkin, Ph.D, 2008; Mr. Nick Karpowicz, Ph.D, 2009; Mr. Jian Chen, Ph.D, 2009; Mr.

Jingle Liu, Ph.D, 2010; Ms. I-Chen Ho, Ph.D, 2011; Ms. Xiaofei Lu, Ph.D, 2011; Ms. Yuting W. Chen, Ph.D, 2011; Ms. Gurpreet Kaur, Ph.D, 2012; Mr. Benjamin Clough, Ph.D, 2012, and Mr. David Brigada, Ph.D, 2012. Selected materials used in this issue come from Dr. Jingle Liu, Dr. I-Chen Ho, Dr. Xiaofei Lu, Dr. Yuting W. Chen, and Dr. Benjamin Clough's research.

I also thank our senior researchers (postdoctoral associates, research associates, research assistant professors, and visiting scholars): Dr. Wang Li, Dr. Zhiping Jiang, Dr. Gyu Cheon Cho, Dr. Masahiko Tani, Dr. Bradley Ferguson, Dr. Samuel Micken, Dr. Xuguang Huang, Dr. Yuchuang Chen, Dr. Jiayin Qin, Dr. Abdellah Menikh, Dr. Zhengguo Lu, Dr. Yunqing Chen, Dr. Albert Redo, Dr. Jianming Dai, Dr. Jin Wook Choi, Dr. Abul Azad, Dr. Ying Hu, Dr. Wei Liang, Dr. Yuguang Zhao, Dr. Cunlin Zhang, Dr. Guozhong Zhao, Dr. Yan Zhang, Dr. Hongwei Zhao, Dr. Hongkyu Park, Dr. Etienne Gagnon, Dr. George Gehring, Dr. Bianca Jackson, Dr. Liangliang Zhang, Dr. Yan Peng, and Dr. Ilya Vugmeyster. They are key players in our group, and have dedicated their time and effort to advancing THz research.

This special issue is dedicated to my former heroine, Dr. Hua Zhong. She earned a B.S. from Peking University, and received a Ph.D in Physics at Rensselaer Polytechnic Institute in 2006. She made an impact in the development of THz science and technology. She was the first researcher, together with her colleague Dr. Xu Xie, to use THz waves for defect detection in thermal insulating foams for the NASA's space shuttle program. She was also the first one to report the THz wave emission pattern from laser induced air plasma with two-color laser excitation, which was important to develop intense broadband THz source with laser pulses. Dr. Hua Zhong returned to China to serve her motherland right after graduation. Unfortunately, she was diagnosed with cancer when she served as a volunteer for the Beijing Olympic Games. After fighting cancer for five years, Dr. Hua Zhong passed away on December 8, 2013 at the young age of 35. I am writing this paragraph with tears, remembering her smiling face, soft voice, creative paintings, and her love. This issue shall celebrate Dr. Hua Zhong's young life. She is forever my heroine.

Xi-Cheng Zhang



Xi-Cheng Zhang—Parker Givens Chair of Optics, assumes Directorship of The Institute of Optics, University of Rochester (UR), NY, a foremost institution in optics and optical physics research and education, on 1/1/2012. Prior to joining UR, he pioneered world-leading research in the field of ultrafast laser-based terahertz technology and optical physics at Rensselaer Polytechnic Institute (RPI), Troy NY (1992–2012). At RPI, he is the Eric Jonsson Professor of Science; Acting Head at the Department of Physics, Applied Physics & Astronomy; Professor of Electrical, Computer & System; and Founding Director of the Center for THz Research. He is co-founder of Zomega Terahertz Corp. With a B.S. (1982) from Peking University, he earned the M.S. (1983) and Ph.D degree (1985) in Physics from Brown University, RI.

Previous positions included Visiting Scientist at MIT (1985), Physical Tech. Division of Amoco Research Center (1987), EE Dept. at Columbia University (1987–1991); Distinguished Visiting Scientist at Jet Propulsion Lab, Caltech (2006). He holds 27 U. S. patents, and is a prolific author and speaker. He is a Fellow of AAAS, APS (lifetime), IEEE, OSA (lifetime), and SPIE (lifetime). Dr. Zhang is serving as Editor-in-Chief of Optics Letters (2014–2016).

His honors and awards include: IRMMW-THz Kenneth Button Prize (2014); OSA William F. Meggers Award (2012); IEEE Photonics Society William Streifer Scientific Achievement Award (2011); Rensselaer William H. Wiley 1866 Award (2009); Japan Society for the Promotion of Science Fellowship & NRC-CIAR Distinguished Visiting Scientist, Ottawa, Canada (2004); and First Heinrich Rudolf Hertz Lecturer, RWTH, Aachen, Germany (2003). He also served two years as a Distinguished Lecturer of IEEE/LEOS. He received Rensselaer Early Career Award (1996), Research Corporation Cottrell Scholar Award (1995), NSF Early Career Award (1995), K.C. Wong Prize, K.C. Wong Foundation, Hong Kong (1995), NSF Research Initiation Award (1992). In 1993–1994, he was an AFOSR-SRPF Fellow at Hanscom Air Force Base.