

Inaugural Editorial

WELCOME to the IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY! Our primary goal is to bring together in one forum the diverse, global communities that make up terahertz science and techniques. Our mission statement, “*Expanding the Use of the Electromagnetic Spectrum*” is consistent with our roots in the engineering community and expresses our desire to extend science and technology into applications for the betterment of humankind. The transactions targets high impact papers with broad appeal to the rapidly expanding terahertz community. The high standards of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES will be maintained, but the scope of these transactions will extend to fields and activities that are outside of the traditional RF and microwave society. We are pledged to provide a high quality, comprehensive publication that spans a wide spectrum of terahertz activities and developments, while at the same time helping to bridge the technology gap between the RF and photonics communities. A personal goal of the editor-in-chief is to enrich the readers’ experience by exposure to cross disciplinary developments in the field that they might otherwise miss. The IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY brings together in a single focused journal, the very broad range of topics and technologies that encompass THz techniques and applications. The editorial board is organized by topic area and has a primary goal of reviewing submitted papers and deciding on publication status within three months. Accepted papers will be posted on-line on *IEEEXplore* within approximately six weeks of final acceptance. This rapid posting of high-quality papers will bring new ideas more quickly to the fore and stimulate discussion and distribution without compromising the peer review process. In keeping with the varied scope of the THz field, the topical editors of the transactions will frequently re-evaluate their emphasis and update their committee members to intelligently respond to trends and to the suggestions of the transactions contributors and readers.

The release of this **Inaugural Print Issue** and simultaneous electronic posting, follows a comprehensive solicitation and review process that was intended to give the reader a broad introduction to the THz field with a large number of overview and review papers on THz technologies and applications from notable researchers. Future issues will follow an open submission process with accepted papers appearing on the IEEEXplore site prior to release of the print copy. As can be seen from the list of 26 technical paper titles in the Table of Contents, the **Inaugural Issue** covers devices and instruments, basic science, a diverse range of applications as well as general and specific measurement techniques. There are papers from astronomers, chemists, physicists, engineers, biochemists, physicians, and even art historians. They come from university, industry, private, and government research groups worldwide. Although we have many

disciplines and application areas represented, there are equally as many we have not been able to include. These will be sprinkled into future issues as will highlighted papers from the various THz conferences that support our diverse community. A continuing special interest feature, “THz Pioneers” has been included to help introduce new researchers to those individuals who have had long term contributions and major impact on the THz field.

The editorial board, as well as the many individuals within the IEEE Microwave Theory and Techniques Society, who have been working very hard behind the scenes for more than a year to bring this publication to fruition, sincerely hope you will find IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY useful, relevant, and most important, stimulating to your research and development efforts and a positive contribution to your career development. We all hope the publication serves your interests, and that in turn you will serve the interests of the THz community by considering the Transactions a primary outlet for your ideas, your inventions, and your reporting.

Yours sincerely,

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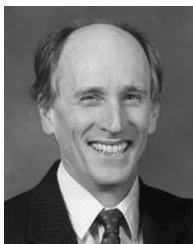


Peter H. Siegel (S’77–M’83–SM’98–F’01) received the B.A. degree from Colgate University, in 1976, and the Ph.D. degree from Columbia University, in 1983.

He holds appointments as Faculty Associate in Electrical Engineering and Senior Scientist in Biology at Caltech and Senior Research Scientist and Technical Group Supervisor for Submillimeter Wave Advanced Technology (SWAT), Jet Propulsion Laboratory, Pasadena, CA. He has been working in the areas of millimeter and submillimeter-wave technology and applications for 35 years and has

PI’d or co-I’d more than 75 R&D programs and been involved in four major space flight instruments. He has published more than 275 articles in the THz field and has given more than 75 invited talks in the U.S. and abroad on this subject. At JPL, he leads a group of 20+ research scientists and engineers developing THz technology for NASA’s near and long term space missions as well as for several DoD applications. At Caltech, he is involved in new biological and medical applications of THz. His current interests are split between traditional Earth, planetary and astrophysics applications and new THz applications in medicine and biology.

Among many other duties, Dr. Siegel chairs the International Society for Infrared, Millimeter and Terahertz Waves (IRMMW-THz), the oldest and largest venue devoted to the field of far-IR techniques, science and applications, and he served as conference organizer and chair for IRMMW-THz 2008 in Pasadena. He has served as an IEEE Distinguished Microwave Lecturer, co-chair and chair of MTT Committee 4-THz Technology, a TPC and Speaker’s bureau member, and as organizer and chair of seven special sessions at the IEEE International Microwave Symposia. He is extremely pleased, and very excited to be involved in the formation and launching of the IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY. (His Web Page: <http://www.thz.caltech.edu>.)



Dylan F. Williams (M'80–SM'90–F'02) received the Ph.D. degree in electrical Engineering from the University of California, Berkeley in 1986. He joined the Electromagnetic Fields Division of the National Institute of Standards and Technology, Boulder, CO, in 1989, where he develops electrical waveform and microwave metrology. He has published over 80 technical papers.

Dr. Williams is the recipient of the Department of Commerce Bronze and Silver Medals, the Astin Measurement Science Award, two Electrical Engineering Laboratory's Outstanding Paper Awards, two Automatic RF Techniques Group (ARFTG) Best Paper Awards, the ARFTG Automated Measurements Technology Award, and the IEEE Morris E. Leeds Award. He also served as Editor of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES from 2006 to 2010.



Sharri Shaw was born in Michigan, and currently resides in Boulder, CO. She received the B.A. degree in English and a minor in psychology, from Saginaw Valley State University, in 1994. She continued her studies in 2001 in the Master in Education with Initial Certification (M.Ed.) program at Aquinas College, where she received her Secondary Level Teacher Certification.

From 2002 to 2005, she was a teacher in Michigan. From 2006 to 2010, she was the Assistant Editor of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES. She currently holds the same position with *IEEE Microwave Magazine*, and also serves as the Publications Administrator for the IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY.

TOPIC EDITORS



Stefano Alberti received the Ph.D. degree from the Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland, in 1991, with his research dedicated to the study of quasi-optical gyrotrons.

After a two year post-doctorate at MIT, Cambridge, where he worked on CARM's and X-Band relativistic-TWT, he returned in 1993 to the Centre for Plasma Physics Research (CRPP), EPFL. Since then, within the European high-power gyrotron development program, he worked at CRPP developing and testing high-power high-frequency gyrotrons for a variety of EC-system installed on magnetically confined plasma experiments, such as TCV at CRPP, Tore-Supra, W7-X and presently ITER. In parallel to this activity, he contributed to the design, installation and testing of complete electron-cyclotron system from "plug" to plasma for these same experiments. On TCV he actively contributed on performing electron-cyclotron heating and current-drive experiments. Since 2008, he is responsible for the development of frequency-tunable gyrotrons for DNP-enhanced NMR-spectroscopy. He is currently Lecturer at EPFL, where he teaches an introductory course in plasma physics. He is the author or coauthor of over 60 refereed publications.



René Beigang received the Diploma and Ph.D. degrees from the University of Hannover, Hannover, Germany.

He spent 3 years as a post-doctorate and visiting scientist at the IBM T.J. Watson Research Center, Yorktown Heights, NY. He was Associate Professor at the Free University of Berlin and the University of Kaiserslautern. He is now a full professor at the Department of Physics of the University of Kaiserslautern. Since 2005, he is also Head of the Department on Terahertz Measurement and Systems of the Fraunhofer Institute for Physical Measurement Techniques. His current research interests include nonlinear optics, generation and application of THz radiation, THz spectroscopy, applications of THz radiation in science and technology, realization and investigation of THz meta materials. (His homepage: <http://www.physik.uni-kl.de/beigang>).



A. Giles Davies received the B.Sc. degree in chemical physics from the University of Bristol, Bristol, U.K., in 1987, and the Ph.D. degree in semiconductor physics from the University of Cambridge, Cambridge, U.K., in 1991.

He is currently Professor of Electronic and Photonic Engineering at the University of Leeds, Leeds, U.K. His research interests concentrate on the electrical and optical properties of low-dimensional and nanostructured electronic systems, and multilayered semiconductor devices, with particular recent focus on the development of terahertz frequency systems and the exploitation of biological processes for nanoscale assembly.



Jack East received the Bachelors' and Ph.D. degrees from The University of Michigan.

He is currently with the Electrical Engineering and Computer Science Department, The University of Michigan, where he conducts research in the areas of high-speed microwave device design and fabrication, circuit modeling and characterization and THz devices.

Dr. East is a member of the IEEE P1785 Standards Committee for Rectangular Metallic Waveguides and their interfaces, MTT TCC 4 (Terahertz Technology and Applications) and an area editor for the new IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY.



Gian Piero Gallerano received the Ph.D. degree in physics from the University of Rome, Italy, in 1980, with a thesis on the realization of a tunable color center laser in the near infrared.

In 1981 he was a Visiting Fellow at the Technical University Hannover, Germany. In 1983 he joined the High Power Laser Laboratory, ENEA Research Center, Frascati, Italy, to work on the development of infrared free electron lasers (FEL). In 1991 he was a Visiting Scholar at the Ginzton Laboratory, EE Department, Stanford University, CA. His work

on FELs lead to the realization of the ENEA Compact FEL (90–150 GHz) and of the Compact Advanced THz Source, FEL-CATS (0.4–0.7 THz). From 2001 to 2004 he has been the Coordinator of the European project THz-BRIDGE involving ten research institutes in the study the interaction of THz radiation with biological systems. From 2005 to 2007 he has been in charge of the ENEA participation in the European project EUROFEL. He is currently the Head of the Radiation Sources Laboratory at ENEA Frascati. His areas of interest include generation of THz radiation and its application in the biological, biomedical, environmental and art conservation fields, THz imaging techniques, coherent emission from RF modulated electron beams, free electron lasers, optical design and diagnostics in the infrared. He has published over 100 papers in international journals.

Dr. Gallerano has chaired the "35th International Conference on Infrared, Millimeter and THz Waves" IRMMW-THz 2010 held in Rome, Italy, September 5–10, 2010. He has been a member of the Italian Physical Society since 1981 and is currently an associate member of the Bioelectromagnetics Society.



Erich N. Grossman received the A.B. degree in physics from Harvard College, Cambridge, MA, in 1980, and a Ph.D. degree, also in physics, from the California Institute of Technology, Pasadena, in 1987. His thesis work involved development of an ultra-low noise, heterodyne receiver for 2 THz astronomy.

From 1988 to 1989, he was a post-doctoral fellow at the University of Texas at Austin, and in 1989, he joined the National Institute of Standards and Technology, Boulder, CO, where he is now a physicist in the Optoelectronics Division. His work at NIST focuses on infrared and submillimeter system development.

Dr. Grossman's notable accomplishments include the development and demonstration of the world's highest frequency, high efficiency lithographic antennas, the world's highest frequency Josephson junctions, (awarded a Department of Commerce Gold Medal in 1993), and early conception and development of the SQUID multiplexer, first enabling large monolithic arrays of superconducting detectors. More recently, he has developed several 0.1–1 THz cameras for security applications. He is also chair of the Metrology Working Group for the DARPA Terahertz Electronics program.



Peter Uhd Jepsen (M'10) received the M.Sc. degree in physics and chemistry from Odense University, Denmark, in 1994, and the Ph.D. degree in natural sciences from Århus University, Denmark in 1996.

He was at the University of Freiburg, Germany from 1996 to 2004, working with terahertz time-domain spectroscopy. From 2005 he was Associate Professor at the Technical University of Denmark (DTU), and since 2008 Professor and Head of the Terahertz Technologies and Biophotonics group at DTU. In 2008/2009 he was Visiting Professor at

Osaka University. His research areas include photonics-based THz technology, broadband THz spectroscopy for chemical sensing, imaging, chemistry, and water dynamics in the THz range, and time-resolved THz spectroscopy of ultrafast phenomena in the THz range.



Kodo Kawase received B.S. degree in electronic engineering from Kyoto University in 1989, and Ph.D degree in electronic engineering from Tohoku University in 1996.

He became an Initiative Researcher at RIKEN in 2001. He became a Professor of Graduate School of Engineering, Nagoya University, Japan, in 2005. He has been conducting research activities in several directions within the THz field. He developed several types of widely tunable THz sources using nonlinear optical effects, and suggested a whole range of real-

life applications. He has published more than 130 articles in the THz field and has given more than 160 invited talks on this subject.

Dr. Kawase received the 1997 Young Scientist Award from the JSAP, the 1998 Excellent Presentation Award, the 2000 and 2006 Prize of Laser Engineering from the Laser Society of Japan, the 2002 Marubun research and encouragement award and 2006 Marubun Special Research Award by the Marubun Research Promotion Foundation (MRPF), and the the 2005 Young Scientists' Prize by the Commendation for Science and Technology by the Minister of Education, Culture, Science and Technology (MEXT).



Martin Koch was born in Marburg, Germany in 1963. He received the Diploma and Ph.D. degree from the University of Marburg in 1991 and 1995, respectively.

From 1995 to 1996 he was a post-doctorate at Bell Labs/Lucent Technologies, Holmdel, NJ. From 1996 to 1998 worked in the photonics and optoelectronics group at the University of Munich. From 1998 to 2008 he was associate professor at the Technical University of Braunschweig. In 2003, he did a three-month sabbatical at the University of

California in Santa Barbara. Since 2009 he is full professor of physics at the Philipps University Marburg, Germany. His research interests are terahertz systems and their applications, semiconductor disk lasers and ultrafast spectroscopy on semiconductors.

In 2003, Dr. Koch was awarded the Kaiser-Friedrich Research Prize.



Nuria Llombart received the Electrical Engineering degree and Ph.D. degree from the Polytechnic University of Valencia, Spain, in 2002 and 2006 respectively.

During her Master's degree studies she spent one year at the Friedrich-Alexander University of Erlangen-Nuremberg, Germany, and worked at the Fraunhofer Institute for Integrated Circuits, Erlangen, Germany. From 2002 until 2007, she was with the Antenna Group at the TNO Defence, Security and Safety Institute, The Hague, The

Netherlands, working as Ph.D. student and afterwards as researcher. From 2007 until 2010, she was a Post-Doctoral Fellow at the California Institute of Technology, working for the Sub millimeter Wave Advance Technology group of the Jet Propulsion Laboratory (JPL), Pasadena, CA. Currently, she holds a "Ramón y Cajal" fellowship at the Optics Department of the Complutense University of Madrid, Spain, while she continues to be an affiliate at JPL, Pasadena. Her research interests include the analysis and design of planar antennas, periodic structures, reflector antennas, lens antennas, waveguide structures, with emphasis in the THz range.

Dr. Llombart was co-recipient of the H. A. Wheeler Award for the Best Applications Paper of 2008 in the IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION. She was also a co-recipient of an Honorable Mention at the 2010 European Conference of Antennas. She serves as Topical Editor for the IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY.



Imran Mehdi (F'10) received the B.S.E.E. degree in 1985, the M.S.E.E. degree in 1986, and the Ph.D. degree in 1990, all from the University of Michigan.

He is currently Principal Member of Engineering staff at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena. His responsibilities include developing THz components and subsystems for current and future NASA missions. He joined JPL in 1990 where his first task included the design and fabrication of low-parasitic planar Schottky diodes for submillimeter-wave applications. These devices

were implemented on the ozone monitoring Microwave Limb Sounder instrument which is still operational, as well as the MIRO instrument which represents the first submillimeter-wave receiver that will rendezvous with a comet in 2014. From 1999, he led the effort of developing broadband solid-state sources from 200 to 2500 GHz for the Heterodyne Instrument for Far Infrared (HIFI) on the Herschel Space Observatory, a cornerstone European Space Agency mission currently in space. This effort led to realization of wide-band solid-state sources in the THz range enabling ground-breaking astrophysics observations in space as well as at many ground-based observatories. His current interests include both mm and sub-mm wave devices, semiconductor fabrication technology, high-frequency instrumentation, and heterodyne receivers for miniature systems.



Gun-Sik Park (M'06) received the B.S. degree in physics education from Seoul National University in Korea and the Ph.D degree in physics from the University of Maryland, College Park, in 1978 and 1989, respectively.

During 1987–1995, he worked at Naval Research Laboratory, Washington, DC, through Omega-P, Inc. In 1995, he joined Seoul National University and currently is a Professor in the Department of Physics and Astronomy, and also jointly with the Department of Electrical Engineering at Seoul National University.

He leads the Center for THz-Bio Application Systems (2009–2018) at Seoul National University supported by the Ministry of Education, Science and Technology of Korea as a Director. His service to journal editor includes *Journal of Korean Physical Society* (JKPS), *Journal of New Physics*, and the *THz Science and Technology*. He serves as a topical editor for IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY, and as a technical committee member of IEEE Electron Devices Society in Vacuum Electronics since 1999. He was a conference chair for 4th IEEE International Vacuum Electronics Conference in 2003 held in Korea and is a co-chair for 34th International Conference on Infrared, Millimeter, and Terahertz Waves in 2009 held in Korea. He is the author of over 100 journal publications in the areas of high power microwaves to terahertz waves.



Christopher Walker has over 25 years experience designing, building, and using state-of-the-art receiver systems for THz astronomy. He is a Professor of Astronomy and an Associate Professor of Optical Sciences and Electrical Engineering at the University of Arizona (UofA). He has worked in industry (TRW Aerospace and JPL) as well as academia. As a Millikan Fellow in Physics at Caltech, he worked on the development of low-noise, SIS waveguide receivers above 400 GHz and explored techniques for etching waveguide out of silicon. On joining the UofA faculty in 1991 he began the Steward Observatory Radio Astronomy Lab (SORAL), which has become a world leader in developing THz receiver sys-

tems for astronomy and other remote sensing applications. These instruments are multi-institutional efforts, with key components coming from JPL, several universities, and a number of industrial partners. He manages and coordinates these efforts. Instruments developed by Prof. Walker's team have served as primary facility instruments at the Heinrich Hertz Telescope on Mt. Graham, AZ, and the AST/RO telescope at the South Pole. He is leading the effort to design and build the world's largest (64 pixels) submillimeter-wave heterodyne array receiver (SuperCam). He is also PI of the NASA funded long duration balloon project "The Stratospheric THz Observatory (STO)". He has published numerous papers on star formation and protostellar evolution. He has served as dissertation director for nine Ph.D. students.