THE Time has come once again to chronicle recent advances in the vibrant and dynamic field of vacuum electronics. This Special Issue, published by the IEEE TRANSACTIONS ON ELECTRON DEVICES, follows successful past issues published every four or five years since 2001. Dr. David Abe and Dr. David Whaley headed the group of Guest Editors for this issue, relying heavily on the expertise and dedication of their fellow Guest Editors, Dr. Jinjun Feng, Dr. John Jelonnek, and Dr. Lalit Kumar. Together, manuscripts covering the wide range of topics found within the following pages were ushered through a rigorous peer-reviewed process to provide a snapshot of the state-of-the-art in vacuum electronics technology for 2018. In a testament to the vitality and widespread activity in the field, contributions to this issue were submitted nearly equally from Europe, Asia, and the Americas. The subject matter of these contributions spans such a wide swath of applications that it is difficult to imagine that our lives are not impacted in some way every day by the benefits that this technology area provides. Communications, radar, accelerator and fusion research, satellite data links, and electronic defense are but a few examples.

The manuscripts in this issue have been grouped according to the topic. The order of the topics within the issue or the order of the individual papers within each topical area is not an indication of the relative importance of that group or paper. All papers contained herein are excellent and are the result of diligent, novel, and inspired work on the part of each and every author.

The issue starts out reporting on research related to the heart of every vacuum electronics device (VED)—the cathode. Although cathodes have powered VEDs for over three quarters of a century, vital progress is still being made to improve performance on several fronts. A consortium of researchers from the U.S. government, academia, and industry reports on efforts to improve fundamental understanding of the elusive scandate cathode, as well as investigate new low-work-function perovskite materials and alternative methods of cathode fabrication. Understanding of electron emission from real-world field emission cathodes is the subject of a highly recommended paper from Dr. Muhammad Zubair of the Singapore University of Technology and Design, Singapore, and may help move the cold cathode closer to mainstream VED implementation. The issue continues with advances in multibeam devices with two outstanding papers from Mr. Michael Boyle of L3 Electron Devices, Torrance, CA, USA, and Dr. Armel Beunas of Thales Electron Devices, Vélizy-Villacoublay, France, detailing parallel developments of the world’s first multibeam inductive output tubes, developed for megawatt-level high-efficiency operation at the European Spallation Source, Lund, Sweden.

Sheet beam devices have proven capable of providing high RF power at high frequency for a variety of applications. Dr. Mark Field of Teledyne Scientific, Thousand Oaks, CA, USA, reports on a 100-W, 200-GHz sheet beam millimeter-wave (mm-wave) amplifier, providing record power in a slow wave amplifier at G-band frequencies. Moving to even higher frequencies, Mr. Linlin Hu of the China Academy of Engineering Physics, Mianyang, China, describes a relativistic backward-wave oscillator frequency extension to over 300 GHz through structure minimization and precision machining producing 600 kW of peak power at a repetition rate of up to 10 Hz. Dr. Carter Armstrong of L3 Electron Devices brings mm-wave microwave power modules (MPMs) to a new performance level with the development and system operation of a 233-GHz, 32-W MPM utilizing a serpentine TWT incorporated into a compact MPM package to power an airborne system capable of real-time through-cloud video imaging.

Gyro devices also figure prominently in this issue, with Dr. Andrey Savilov of the Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia, reporting on large orbit gyrotron harmonic power generation at frequencies up to 0.65 THz utilizing the fourth cyclotron harmonic. Practical improvements to gyro-device operation are suggested by Dr. Ioannis Pagonakis of the Karlsruhe Institute of Technology, Karlsruhe, Germany, demonstrating alternate spent beam deceleration schemes for gyrotron depressed collectors and by Dr. Jeff Neilson of Calabazas Creek Research, Inc., San Mateo, CA, USA, implementing an HE11 coupler internal to the gyrotron vacuum envelope eliminating the need for the large external quasi-optical matching optics unit typically used. Systems and applications papers also comprise a full topical group. On-orbit reliability of space TWT amplifiers for two satellite fleets is examined by Dr. Eric Nicol of Space Systems Loral, Palo Alto, CA, USA, and Dr. Armel Beunas of Thales Electron Devices brings mm-wave microwave power modules (MPMs) to a new performance level with the development and system operation of a 233-GHz, 32-W MPM utilizing a serpentine TWT incorporated into a compact MPM package to power an airborne system capable of real-time through-cloud video imaging.

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Having had the privilege of serving as Guest Editors for this Special Issue, we would like to acknowledge the over 150 reviewers who generously contributed their time and expertise during the review process, as well as the IEEE Editorial Staff for expertly handling the myriad of details required to bring this issue together so professionally.

In closing, we observe that the vitality and robustness of the vacuum electronics field is clearly evident in these pages, as has been true for each of the past special issues. Given the arc of VED technology advances coupled with the extraordinary human talent involved in this field, we expect this trend to continue for many decades to come.

David K. Abe (M’88–SM’12–F’15) received the B.S. degree in engineering from Harvey Mudd College, Claremont, CA, USA, in 1981, the M.S. degree in electrical engineering from the University of California, Davis, CA, USA, in 1988, and the Ph.D. degree in electrophysics from the University of Maryland, College Park, MD, USA, in 1992.

He was involved in interdisciplinary projects in pulsed power, high-power microwave generation, and electromagnetic effects at the Lawrence Livermore National Laboratory, Livermore, CA, USA, Berkeley Research Associates, Inc., Beltsville, MD, USA, and the U.S. Army Research Laboratory, Adelphi, MD, USA. He joined the U.S. Naval Research Laboratory, Washington, DC, USA, in 1996, where he is currently the Head of the Electromagnetics Technology Branch, a multidisciplinary group pursuing basic and applied research in both vacuum electronic and solid-state devices with applications in radar, communications, electronic warfare, and RF directed energy.

Dr. Abe was an Elected Member of the IEEE Nuclear and Plasma Sciences Society (NPSS) Administrative Committee and currently serves on the NPSS Plasma Science and Applications Executive Committee. He has served on the IEEE Community in various capacities as a Session Organizer and on the technical program committees of numerous conferences, as the Technical Program Chair and the General Chair of the 2012 and 2014 IEEE International Vacuum Electronics Conferences, respectively, as a member of the IEEE Electron Devices Society Technical Committee on Vacuum Electronics, and on the Editorial Board of the IEEE Journal of the Electron Devices Society.

David R. Whaley (M’96–SM’10) received the B.S., M.S., and Ph.D. degrees from the Department of Nuclear Engineering, University of Michigan, Ann Arbor, MI, USA, in 1984, 1985, and 1989, respectively.

He was with the Swiss Federal Institute of Technology, Lausanne, Switzerland, and Northrop Grumman, Chicago, IL, USA. He joined L3 Technologies Electron Devices in 2003, where he currently serves as the Chief Scientist. At L3, he is primarily responsible for TWT development, focusing on high efficiency, wideband, and high-power TW Ts for ECM, radar, and communications applications. He is also responsible for the L3 Cold Cathode TWT development program which has produced TW Ts operating in a variety of frequency bands that employ field emitters as the device electron source.

Dr. Whaley is currently a member of the IEEE Vacuum Electronics Technical Committee, the Association of Old Crows, the IEEE Electron Devices Society, and the Nuclear and Plasma Sciences Society. He was a recipient of the R&D 100 Award for developing the TWT that resulted in the first 50% efficient microwave power module and the US Pentagon Value Engineering Award for successful defense systems implementation of TWT technology advances in 2011, and was named an L3 Engineer of the Year in 2013. He served as the Technical Program Chair and the General Chair for the IEEE International Vacuum Electronics Conference in 2014 and 2016, respectively. He also served as a Guest Editor for the 2010 Special Issue on High Power Microwave Generation of the IEEE Transactions on Plasma Science.
Jinjun Feng (M’94–SM’06) received the bachelor’s degree from Tsinghua University, Beijing, China, in 1988, and the master’s and Ph.D. degrees from the Beijing Vacuum Electronics Research Institute (BVERI), Beijing, in 1990 and 2001, respectively. Since 1990, he has been with BVERI and has been involved with research and development of millimeter-wave space TWTs, W-band TWTs, higher frequency devices using microfabrication, gyrotrons, field emission devices, and cesium tubes, where he is currently the Vice General Director. He is a fellow of Chinese Institute of Electronics, Beijing, and the Institution of Engineering and Technology, Stevenage, U.K.

Dr. Feng has been a member of IEEE Electron Devices Society (EDS) Vacuum Electronics Technical Committee since 2010. He was the Chair of the IEEE EDS Beijing Chapter from 2011 to 2012 and the IEEE Beijing Section from 2014 to 2015, and has been the Chair of the IEEE China Council since 2016. He was a TPC Chair of the 2015 International Vacuum Electronics Conference, Beijing. He was a TPC Co-Chair of the 8th U.K., Europe, China Millimeter Waves and Terahertz Technology Workshop (UCMMT), Cardiff, U.K., in 2015, and a General Co-Chair of the 9th UCMMT, Tsingdao, China, in 2016.

John Jelonnek (M’97–SM’15) received the Dipl.-Ing. and Dr.-Ing. degrees in electrical engineering from the Hamburg University of Technology (TUHH), Hamburg, Germany, in 1991 and 2000, respectively.

At TUHH, he developed rigorous self-consistent analyses for gyrotron oscillators, in the frequency and in the time domain (slow- and fast-time scales), with particular focus on rigorous time-domain simulation of gyrotron operation at mismatched conditions and injection locking. From 1997 to 2011, he held several different leading positions at industry, including R&D, technology, and business management. Since 2011, he has been the Director of the Institute for Pulsed Power and Microwave Technology, Karlsruhe Institute of Technology, Karlsruhe, Germany, where he is also a Professor of high-power microwave technologies. His current research interests include the research and development of high-power microwave sources, with particular focus on fusion gyrotrons, and application of high-power microwaves to energy efficient industrial processes using dielectric heating and microwave plasma. Research and developments in pulsed-power technologies range from the development of high-power sources to applications in the fields of materials processing and bioelectronics.

Dr. Jelonnek has served as a Guest Editor for the August 2016 T-PS Special Issue on High-Power Microwave Generation of the IEEE Transactions on Plasma Science.

Lalit Kumar (M’89–SM’07) received the Ph.D. degree in physics from the Birla Institute of Technology and Science, Pilani, India.

He served as the Director of the Microwave Tube Research and Development Centre, Bangalore, India, and a Senior Scientist with the Central Electronics Engineering Research Institute (CSIR-CEERI), Pilani. He was the DAAD Fellow at the University of Tübingen, Tübingen, Germany, the Hamburg University of Technology (TUHH), Hamburg, Germany, and Philips, Hamburg. He was a Visiting Research Fellow with Lancaster University, Lancaster, U.K., twice on ESA and British Council projects, respectively. He was an AICTE-INAE Distinguished Visiting Professor with IIT (BHU) Varanasi, Varanasi, India. He attended leadership programs at IIMs, National Institute of Advanced Studies, Bangalore, and JF Kennedy School, Harvard University, Cambridge, MA, USA. He is the Chairman of CEPTAM, DRDO, Delhi, India, and an Adjunct Professor with IIT Roorkee, Roorkee, India. He also conducted research on gyrotron, high power microwave sources: vircator, relativistic magnetron, and magnetically insulated line oscillator, vacuum microelectronic devices, and microwave power transmission. His current research interests include theory and CAD for electron guns, depressed collectors, magnetic focusing systems, interaction structures, and the development of helix- and coupled-cavity-TWTs, multibeam klystron, coaxial magnetron, microwave power modules, and compact transmitters.

Dr. Kumar is a fellow of the Indian National Academy of Engineering, the Institution of Electronics and Telecommunication Engineers (IETE), and the Vacuum Electron Devices and Applications (VEDA) Society, and a member of EXECOM-IEEE Delhi Section, the Indian Physics Association, the Indian Vacuum Society, and the Magnetic Society of India. He was a recipient of the DRDO Agni Award in 2003 and 2013, the IETE Ram Lal Wadhwa Award, the IETE-IRSI(83) Award, the IETE-JC Bose Award, and the CEERI Best Project Award. He was the Founder President of the VEDA-Society from 2005 to 2007, a member of the IEEE Electron Devices Society Technical Committee on VED from 2006 to 2015, and the General Chair of XII IEEE-IVEC-2011, Bangalore.