Introduction to the Special Issue on Microwave and Millimeter-Wave Photonics

WELCOME to this third Joint Special Issue of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES and JOURNAL OF LIGHTWAVE TECHNOLOGY devoted to microwave and millimeter-wave photonics. Microwave photonics can be defined as the study of photonic devices operating at microwave frequencies and their applications in microwave systems. From pioneering experiments in the late 1970's, the field has expanded to produce a number of applications of commercial importance. These include the remoting of antennas for cellular and micro-cellular radio using analog fiber links, the distribution of cable-television signals, signal processing using optical techniques for phased-array antenna beam forming, and opto-electronic probing of microwave and millimeter-wave monolithic integrated circuits.

The first Special Issue published in May 1990 and edited by Prof. Peter Herczfeld of Drexel University, Philadelphia, PA, contained 33 papers, the second, published in September 1995 and again edited by Herczfeld, with the assistance of four deputy editors distributed around the world, contained 38 papers. This third Special Issue goes to press less than two years after the previous one but such has been the development of interest in the field that we received some 60 manuscripts for consideration. From these, with assistance from an international team of expert reviewers, we have selected 41 papers for publication in this Joint Special Issue. A few other papers whose review/revision cycle could not be completed within the tight publication schedule required for this Special Issue will appear in subsequent regular issues of this TRANSACTIONS. In carrying out the paper review process we took care to ensure that for any paper in which one of the editors had an involvement, responsibility for its handling was allocated entirely to the other editor.

We have divided the papers into six general subject headings. The first three are directed to enabling technologies and cover techniques for the generation of microwave photonic signals, detectors for microwave photonic signals, and optically controlled microwave devices. We then move to applications of microwave photonics with three sections addressing analog optical links, photonic techniques for microwave-signal processing, and beamforming for microwave phased-array antennas.

We have also included a memoriam to our late colleague, Brian Hendrickson, whose recent passing has saddened the photonics community, but whose accomplishments and contributions to our field will always be remembered with both affection and respect.

In preparing this Special Issue, we have benefited from the advice of Prof. Peter Herczfeld, Prof. Robert Trew, Editor of the IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, and members of the MTT-S Technical Committee on Lightwave Technology, especially Dr. Norman Dietrich and Dr. Reinhard Knerr.

Special thanks are due to the large team of reviewers who undertook the detailed examination of the submitted manuscripts. They were tremendously helpful in carrying out their work within a tight time schedule while providing detailed technical comments to the authors. Finally, we would like to thank the authors for their support of this Special Issue, for their help in adjusting the lengths of their papers to meet the page budget and for meeting deadlines in order to allow this Special Issue to meet its press date.

We hope that this Special Issue will provide a useful cross section of the state of the art of microwave photonics. Commercial exploitation and research results in this field progress rapidly and we suspect there will be a need for a further Special Issue in the not too distant future.

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From 1980 to 1983, he was a Staff Member at Lincoln Laboratory, Massachusetts Institute of Technology, Cambridge, where he worked on GaAs monolithic millimeter-wave integrated circuits for use in phased-array radar. He returned to the U.K. in 1983, to take up a lectureship in telecommunications at Queen Mary College, University of London, moving to University College London, London, U.K., in 1986, where he is currently Professor of opto-electronics and Head of the Opto-electronics and Optical Networks Group. He has published over 100 papers on microwave and opto-electronic devices and their systems applications and is presenter of the video "Microwave Opto-electronics" in the IEEE Emerging Technologies series. His current research interests include microwave-bandwidth tunable lasers, optical control of microwave devices, mode-locked lasers, optical phase-locked loops, optical frequency synthesis, dense WDM networks, optical soliton transmission, and the application of optical techniques to microwave systems.

Prof. Seeds is Vice-Chairman of Commission D (Electronics and Photonics) of the International Union for Radio Science (URSI), and a member of the technical committee on Lightwave Technology of the IEEE Microwave Theory and Techniques Society. He has served on the program committees for many international conferences, and is Co-Chair for the forthcoming IEEE MTT/LEOS International Topical Meeting on Microwave Photonics (MWP'97) to be held in Duisburg, Germany.

Ronald D. Esman (S'82–M'85–SM'95) received the B.A. degree, *magna cum laude*, in physics and mathematics from Kalamazoo College, Kalamazoo, MI, in 1981, and the M.S. and D.Sc. degrees in electrical engineering from Washington University, St. Louis, MO, in 1983 and 1986, respectively. His doctoral thesis research was in the areas of fabrication, large-signal analysis, and characterization of high-speed electroabsorption avalanche photodetectors.

In 1980, he interned at Oak Ridge National Laboratory, Oak Ridge, TN, where his research included characterization and passivation of polycrystalline Si solar cells. He joined the Naval Research Laboratory (NRL), Washington, DC, in 1986, where he began work in the fields of high-speed optoelectronics, optical-microwave interactions, semiconductor laser noise and spectral characteristics, and fiber optics. From 1990 to 1991, he was with NIST, Boulder, CO, where he studied high-speed coherent optical transmission and measurement techniques at NTT Transmission Systems Laboratory, Yokosuka, Japan. He is presently Head of the Microwave Photonics Section at NRL, which he is involved in RF array beamforming, remote sensing, RF signal processing, photodetector nonlinearities, and picosecond optical probing. His primary areas of specialization are basic studies in the physics of microwave transmission using fiber optics, including the study of laser sources, electro-optic modulators, laser-fiber interactions, fiber optics (e.g., dispersion, nonlinearities, polarization), high-speed photodetectors, conception, analysis, construction, and evaluation of photonic subsystems for Navy applications, coherent and incoherent signal processing applications, and high-speed opto-electronic component development, analysis, and characterization.

Dr. Esman is a member of Sigma Xi, the Optical Society of America, and Phi Beta Kappa. He serves on the the technical committee on Lightwave Technology of the IEEE Microwave Theory and Techniques Society.