Editorial: Introduction to the Special Issue on Medical Application and Biological Effects of RF/Microwaves

IN RECENT years, there has been a dramatic increase in the utilization of microwave/radio frequency (RF) technologies in the commercial world, specifically in communications. This has resulted in the widespread availability of improved microwave/RF components and systems of much smaller sizes and at much lower prices than were previously possible. This has, in turn, resulted in a proliferation of many new ideas for the use of electromagnetic energy in medical therapies which were not previously considered practical.

For example, the use of RF and microwaves in cancer therapy in human subjects is well documented, and is currently in use in many cancer centers. The utilization of RF in the treatment of supraventricular arrhythmias in human subjects is currently employed by every major hospital. Similar modalities are also used in human subjects for the treatment of benign prostatic hyperplasia (BPH).

Despite these advances, there is considerable effort being expended on improvement of the technology. Particularly, the development of better antennas and antenna systems (the critical component in microwave therapy) as well as that of better coupling mechanisms of RF energy still dominate the area of hyperthermia.

This special issue of the IEEE TRANSACTIONS ON MICROWAVE THEORY and TECHNIQUES presents current papers on the subjects of Biological Effects of Microwaves and Microwave Applications in Medicine. It is divided into four major sections.

The first group of papers deals with the broad subject of RF/microwave hyperthermia in cancer treatment, and includes subjects such as the utilization of microwave radiometry in hyperthermia therapy, microwave prostatic hyperthermia, various RF/microwave focusing techniques and predictions, techniques for achieving deep induction hyperthermia, as well as studies demonstrating microwave hyperthermia possibilities in the treatment of tumors of the head.

The second group of papers deals with the optimization of thermal effects in cardiology, in part through better design of microwave antennas, and better catheter/probes at RF (kHz) frequencies. A number of papers dealing with cardiac therapy are presented, specifically in the areas of cardiac ablation and microwave balloon angioplasty.

The third group deals with electromagnetic energy absorption in human subjects, specifically in the human head and neck. To assure coverage in this area as requested by many of our MTT-S colleagues, the paper entitled "A Study of the Handset Antenna and Human Body Interaction," by Michael Okoniewski and Maria Stuchly was invited.

The fourth section contains papers on modeling of a number of biological devices and systems, a model driven approach to microwave diagnostics, effects of microwave irradiation of the spinal cord, interaction of microwave fields with the nervous system, an evaluation of the influence of pulsed microwave on isolated hearts, a study of open-ended coaxial probe models, and image reconstruction of a complex cylinder illuminated by TE waves.

It is obvious that the fields of biological effects of microwave and microwave applications in medicine represent strongly developing areas of research, which have great potential for stimulating new approaches in the future.

Thanks are due to the reviewers for their thorough and timely response, as well as to Dr. Harel D. Rosen for his assistance in editing many of the accepted papers, and to Danielle Rosen and Ronnie Kasian for their assistance in managing the project.

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Arye Rosen (M'77–SM'80–F'92) was born in Israel in 1937. He received the B.S.E.E. degree (cum laude) from Howard University, Washington, DC, the M.Sc.E. degree from Johns Hopkins University, Baltimore, MD, the M.Sc. degree in physiology from Jefferson Medical College, and the Ph.D. degree in electrical engineering from Drexel University, Philadelphia, PA.

He is a Senior Member of the Technical Staff at the David Sarnoff Research Center (formerly RCA Laboratories) in Princeton, NJ, which he joined in 1967 and where he is currently responsible for research and development in the areas of millimeter-wave devices and circuits and microwave optical interaction. He currently holds an appointment as Center Professor in the Center for Microwave and Light-Wave Engineering at Drexel University, where he has held an appointment as Adjunct Professor in the Department of Electrical and Computer Engineering since 1981. He also holds the title of Associate in Medicine at Jefferson Medical College, where he has been engaged in research in the Division of Cardiology since 1970, specifically in the areas of microwave balloon angioplasty and microwave/RF catheter ablation for the treatment of cardiac arrhythmias, two subjects which are currently being investigated in several medical centers around the world. The author of more than 150 technical papers, he is co-editor of *High-Power Optically Activated Solid-State Switches* (Boston: Artech House, 1993) and of *New Frontiers in Medical Device Technology* (New York: Wiley, 1995), and of six book chapters in the field of engineering and medicine.

Dr. Rosen became a Fellow of the IEEE in 1992 "for innovation in semicondictor devices and circuits for use in microwave systems and for microwave applications to medicine." He is a member of the IEEE MTT-S Technical Program Committee since 1979, MTT-S Technical Committee Chairman on Biological Effects and Medical Applications, he has served as Associate Editor of the IEEE JOURNAL OF LIGHTWAVE TECHNOLOGY (JLT), and is a member of the Editorial Board of Microwave and Optical Technology Letters. He has served on the Technical Committee for the IEEE International Conference on Microwaves in Medicine held in Belgrade, Yugoslavia, in April 1991. He is also a Member-at-Large of the IEEE Health Care Engineering Policy Committee, and has served as a Member of the IEEE Educational Activities Board. He holds 45 United States patents in the fields of engineering and medicine, and is the recipient of numerous achievement and professional awards, including a 1989 IEEE Region One Award "for significant contributions to microwave technology by the invention and development of microwave balloon angioplasty." His biography has been selected for inclusion in *Marquis Who's Who in the World* 1995–1996.

André Vander Vorst (M'64–SM'68–F'86) was born in Brussels, Belgium, in 1935. He received the degrees of electrical and mechanical engineer in 1958 and the Ph.D. degree in applied sciences in 1965 from the Universit Catholique de Louvain, Belgium. In 1965, he received the M.Sc. degree in electrical engineering from Massachusetts Institute of Technology, Cambridge, MA. He is associated with the Universit Catholique de Louvain (UCL) where he became an Assistant in 1958, Assistant Professor in 1962, Associate Professor in 1968, and Professor in 1972.

From 1958 to 1964, he worked on fast switching of magnetic cores. With a NATO fellowship, he was in the U.S. from 1964 to 1966, first at M.I.T., then at Stanford University, both in the field of radio-astronomy. In 1966, he founded the Microwaves Laboratory at UCL, Belgium, which he still heads, starting with research on loaded waveguides and cavities. The laboratory is presently conducting research on atmospheric transmission and diffraction up to 300 GHz, the methodology of designing and measuring active and passive circuits up to 100 GHz, and microwave bioelectromagnetics, namely the transmission between the peripheral and the central nervous system, using microwave acupuncture as a stimulus. He was Head of the Electrical Engineering Department from 1970 to 1972, Dean of Engineering from 1972 to 1975, Vice-President of the Academic Council of the university from 1973 to 1975, President of the Open School in Economic ad Social Politics from 1973 to 1987, all at UCL, Belgium. He has authored or coauthored three textbooks, several chapters, and a variety of scientific and technical papers in international journals and proceedings.

Dr. Vander Vorst is a member of the National Committee of URSI and of various committees on communications, microwaves, and education. He has been active in IEEE Region 8 as well as in the European Microwave Conferences. He is a member of Academia Europaea and The Electromagnetics Academy. He has obtained the Sitel prize 1986, and the meritorious service award of the Microwave Theory and Techniques Society, IEEE 1994. He became a Fellow of the IEEE in 1985 for his contributions in atmospheric microwave propagation, satellite communication earth station design, and numerical analysis of microwave components.