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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: BIO-COMPATIBLE DEVICES AND BIO-ELECTROMAGNETICS FOR BIO-MEDICAL APPLICATIONS

Today research activity is strongly driven by non-invasive exploration of living bodies. Wide-band reflectometry using adequate antennas system represents a possible way, but sometimes more accuracy is required which can be achieved by the use of implantable sensors that can closely investigate the interested tissues and are able to communicate with the external systems. For some applications, this communication can be unidirectional for monitoring purposes, but even in these cases, the transceiver should be carefully designed to obtain the necessary data while generating as low as possible radiofrequency power within the tissues. Blood and/or soft/hard tissue analysis can be based on this technique. The received signal is processed locally or sent to a remote medical center for further processing. The algorithms to extract the information are quite complex, and the low signal to noise ratio makes the analysis even more challenging. A bi-directional communication on the other hand represents a considerable advancement, when the sensor nodes are remotely controlled based on the feedback of the received data, for controlled drug release applications, as an example. Nevertheless, the reduced transmitter-receiver distance and presence of different high-loss tissues introduce strong reflections.

Different technologies should be considered that make the overall scheme efficient and reliable. The following are some important challenges associated with bio-medical applications considered in the Special Section:

1) the surfaces of the implantable devices in contact with the host should be bio-compatible: In the work by Peter and Rosso (*Study of Ti-enriched CoCrMo alloy for dental application*) the peculiar position of metallic materials for production of medical devices is discussed, and in particular a new enriched Co-based composition is proposed for dental application. Macrostructural and microstructural investigations, mechanical and corrosion resistance evaluation, and metal ions release have been carried out to identify the best composition for dental purpose. Bio-compatibility aspects of the surface of the prototyped CoCrMoTi₄ alloy crown are

experimentally analyzed demonstrating its effective use in a human mouth.

2) the sensor lifetime should be long enough to guarantee the system operation over the required period: In the invited paper Hossain et al. (*A miniature energy harvesting rectenna for operating a head-mountable deep brain stimulation device*) creation of a deep brain stimulation device that operates indefinitely without a battery is proposed. From the application standpoint, the developed energy harvesting rectenna facilitates long-term deep brain stimulation of laboratory animals for preclinical research investigating neurological disorders. Testing the functionality of the antenna, rectifier, and stimulator as a whole device in a laboratory arrangement in the case of a representative mice mockup is presented.

3) the intrinsically reduced dimension of the sensor should be able to incorporate the antenna: Song et al. (*A radar-based breast cancer detection system using CMOS integrated circuits*) presents an ultrawideband (UWB) radar-based breast cancer detection system which is composed of a compact UWB antenna array and CMOS integrated circuits such as Gaussian monocycle pulse (GMP) generation circuits, switching matrix circuits and equivalent time sampling circuits. The total size for the prototype module is 45 cm × 30 cm × 14.5 cm in length, width and height respectively, which is dramatically smaller than the conventional detection systems. The proposed system is used to demonstrate a successful detection of 1-cm bacon-based cancer target in the breast phantom.

4) the antenna efficiency should not drop to an unacceptable level due to the reduced dimensions: Rezaeieh et al. (*Microwave system for the early stage detection of congestive heart failure*) presents the design and implementation of an automated ultrahigh-frequency microwave-based system for congestive heart failure (CHF), i.e., fluid accumulation inside the lungs, detection and monitoring. The developed system (software and hardware) makes use of inverse Fourier transform applied to the collected data from the scanning to

visualize the observable in the time domain. These images show the intensity of the reflected signals from different parts of the torso. Using a differential based detection technique, a threshold is defined to differentiate between healthy and unhealthy cases.

The functioning of the developed microwave system by comparing scattering profiles of healthy and unhealthy cases is presented also by a 2-minute video abstract available on the abstract page of the article on IEEE Xplore.

We are pleased with the poles apart arguments the Special Section has succeeded to collect on the recent findings related to bio-medical engineering research. Results in the fields of electronics, medicine, materials science, electromagnetics, signal processing, etc. and more importantly the significance

of the inter-disciplinary aspects between them that provides successful solutions are presented pointing out the importance of such collaborative effort to reach new frontiers in applied science focused on human well-being issues.

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LADISLAU MATEKOVITS (M'94–SM'11) received the degree in electronics engineering from the Institutul Politehnic din București, București, Romania, in 1992, and the Ph.D. (Dottorato di Ricerca) degree in electronics engineering from the Politecnico di Torino, Turin, Italy, in 1995. He joined the Department of Electronics and Telecommunications, Politecnico di Torino, as an Assistant Professor in 2001, where he was appointed Senior Assistant Professor in 2005 and Associate Professor in 2014, respectively. In 2005, he was a Visiting Scientist with the Antennas and Scattering Department, Fraunhofer Institute, Wachtberg, Germany. In 2009, for two years, he was a Marie Curie Fellow with Macquarie University, Sydney, NSW, Australia, where he also held a Visiting Academic position in 2013 and was appointed an Honorary Fellow in 2014. Since 1995, he has been with the Department of Electronics and Telecommunications, Politecnico di Torino, first as a Post-Doctoral Fellow, and then a Research Assistant. He has been invited to serve as a Research Grant Assessor for government funding calls and an International Expert in Ph.D. thesis evaluation by several universities in Australia, India, and Spain. He has

authored over 270 papers, including more than 50 journal contributions, and delivered seminars on these topics all around the world, in Europe, USA (AFRL/MIT-Boston), Australia, and China. His main research activities concern numerical analysis of printed antennas and, in particular, development of new numerically efficient full-wave techniques to analyze large arrays, optimization techniques, and active and passive metamaterials.

Prof. Matekovits is a member of the Organizing Committee of the International Conference on Electromagnetics in Advanced Applications and the technical program committees of several conferences. He was a recipient of various awards in international conferences, including the 1998 URSI Young Scientist Award (Thessaloniki, Greece), the Barzilai Award 1998 (Young Scientist Award, granted every two years by the Italian National Electromagnetic Group), and the Best AP2000 Oral Paper on Antennas, ESA-EUREL Millennium Conference on Antennas and Propagation (Davos, Switzerland). He was the Assistant Chairman and Publication Chairman of the European Microwave Week 2002 (Milan). He serves as an Associated Editor of the IEEE ACCESS and a Reviewer for different journals, including the IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION and the IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS.



TAKAMARO KIKKAWA (S'74–M'76–SM'01–F'10) received the B.S. and M.S. degrees in electronics engineering from Shizuoka University, Shizuoka, Japan, in 1974 and 1976, respectively, and the Ph.D. degree in electronic system from the Tokyo Institute of Technology, Tokyo, Japan, in 1994. He joined NEC Corporation, Tokyo, in 1976, where he conducted the research and development of interconnect technologies for large scale integrated circuits and dynamic random access memories. From 1983 to 1984, he was a Visiting Scientist with the Massachusetts Institute of Technology, Cambridge, MA, USA, where he conducted research on silicon-on-insulator transistors. In 1998, he joined Hiroshima University, Hiroshima, Japan, as a Faculty Member, where he is currently a Professor with the Graduate School of Advanced Sciences of Matter and the Director of the Research Institute for Nanodevice and Bio Systems. From 2001 to 2008, he was appointed as the Senior Research Scientist with the National Institute of Advanced Industrial Science and Technology, Japan, and the Group Leader of low-dielectric-constant material/Cu interconnect technology of Japan's MIRAI Project. He is a Councilor of

Hiroshima University. His research interests include low-permittivity materials, complex permittivity of tumor tissues, impulse-radar-based CMOS integrated circuits, and antenna and propagation for breast cancer detection. He is a fellow of the Japan Society of Applied Physics.



ILDIKO PETER received the M.S. degree in biochemistry from the Università degli Studi di Torino, in 1997, and the Ph.D. degree in material science and engineering and Politecnico di Torino, Italy, in 2001. In 2010, she was a Visiting Researcher with Macquarie University, Sydney, NSW, Australia. She has participated in various European and national projects, being involved at both the technical/research and administrative levels. She is involved in the teaching activity of various second (master's) and third (Ph.D.) level courses in the field of material science. She has co-authored over 90 publications and holds two granted patents. Her research interest is oriented to the development and characterization of light weight alloys by traditional and innovative techniques for automotive and aeronautical industries, the study of metallic materials for biomedical applications, the synthesis and characterization of innovative substrates for advanced electromagnetic applications, and the study of Al and Mg alloys welding and development of coatings on light alloys and on steel substrate for high temperature applications. She has delivered various invited talks and organized special sessions at several conferences.

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KARU P. ESSELLE (M'92–SM'96) received the B.Sc. (Hons.) degree in electronics and telecommunication engineering from the University of Moratuwa, Moratuwa, Sri Lanka, in 1983, and the M.A.S. and Ph.D. degrees in electrical engineering from the University of Ottawa, Ottawa, ON, Canada, in 1987 and 1990, respectively, with a nearly perfect GPA.

He is currently a Professor of Engineering with Macquarie University, Sydney, NSW, Australia, where he was previously the Associate Dean of Higher Degree Research with the Division of Information and Communication Sciences. He had also served as a member of the Executive Division from 2003 to 2008, and the Head of the Department several times, including six months from 2011 to 2012. He was an Assistant Lecturer with the University of Moratuwa, a Canadian Government Laboratory, a Visiting Post-Doctoral Fellow with Health Canada, Ottawa, ON, Canada, a Visiting Professor with the University of Victoria, Victoria, BC, Canada, a Visiting Research Fellow with the University of Western Australia, Crawley, WA, Australia, and a Visiting Scientist with the CSIRO ICT Centre, Marsfield, NSW, Australia.

He has been invited to serve as an International Expert/Research Grant Assessor by several nationwide research funding bodies overseas, including The Netherlands, Canada, Finland, Hong Kong, Georgia, and Chile. He is the Director of the Centre for Electromagnetic and Antenna Engineering, which is in the Concentration of Research Excellence in Wireless Communications. He leads the Implantable Wireless Program of the WiMed Research Centre at the executive level. He has provided expert assistance to more than a dozen companies, including Intel, the Hewlett Packard Laboratory (USA), Cisco Systems (USA), Cochlear, Optus, Locata (USA)/QX Corporation, Silicon Controls, ResMed, FundEd, and Katherine-Werke (Germany). He has authored over 400 research publications and his papers have been cited over 2750 times. His research interests include periodic and electromagnetic band gap (EBG) structures, including frequency-selective surfaces and EBG resonator antennas, metamaterials, dielectric-resonator antennas, leaky-wave antennas, ultrawideband antennas, broadband and multiband antennas, biomedical devices, on-body and through-body wireless communication, millimeter-wave and MMIC devices, antenna and EBG applications in mobile and wireless communication systems, theoretical methods, and lens and focal-plane-array antennas for radio astronomy. He was a recipient of the 2012 Best Published Paper Award in Electronic and Telecommunication Engineering from the IESL New South Wales (NSW) Chapter, the 2011 Outstanding Branch Counselor Award from the IEEE headquarters (USA), the 2009 Vice Chancellor's Award for Excellence in Higher Degree Research Supervision, and the 2004 Inaugural Innovation Award for best invention disclosure. He served in all Macquarie University HDR-Related Committees at the highest level. In addition to the large number of invited conference speeches he has given, he has been an Invited Keynote Speaker of IEEE workshops in Australia and overseas. He is a Guest Editor of the IEEE ACCESS and an Associate Editor of *IET Microwave, Antennas and Propagation*. In 2014, he was elected to the IEEE Antennas and Propagation Society Administrative Committee for 2015-2017. He has served on the technical program committees or international committees for many international conferences. He was the Technical Program Committee Co-Chair of ISAP 2015, APMC 2011, and TENCON 2013, and the Publicity Chair of IWAT 2014 and APMC 2000. He was the Vice Chair of the IEEE NSW Section (2014 and 2015) and Chair of the IEEE NSW MTT/AP Joint Chapter. He is the Vice Chair of the IEEE NSW MTT/AP Joint Chapter, a Counselor of the IEEE Student Branch at Macquarie University, an Advisor of the IEEE MTT Chapter in Macquarie University, and the Foundation Editor-in-Chief of MQEC. He was the Chair of the Educational Committee of the IEEE NSW.

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