IEEE Access Special Section Editorial: Bio-Compatible Devices and Bio-Electromagnetics for Bio-Medical Applications

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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 $CoCrMoTi_4$ 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 $\times$ 30 cm $\times$ 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 invers 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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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.

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ILDIKO PETER received the M.S. degree in biochemistry from the Universita 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. She is acting as a TPC Member of different international conferences and a Reviewer for several journals. She is the European Branch Director of the American Romania Academy. Since 2015, she has served as an Associated Editor of the IEEE ACCESS.

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