The Perspective of Biomedical Electronics

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Abstract

The key factors driving both research and market of biomedical electronics are aging populations, rising healthcare costs, the need for access to medical diagnosis and treatment in emerging and remote regions and in homes, and the fast development of biotechnologies. The applications of biomedical electronics in research, design, and development of biomimetic devices/systems, instruments and appliances that treat intractable neurological disorders, restore health and extend life, and enable biotechnology development is an exciting area of future growth for the electronics industry. It is an area that bridge engineering, biology, and medicine. Great opportunities and challenges of biomedical electronics have attracted tremendous research efforts in both academia and industry.

The major future trends in biomedical electronics are portability, miniaturization, connectivity, humanization, security, and reliability. Portability requires accurate bio-signal sensors/actuators, efficient system power management, ultra-low power electronics, and energy harvesters. Miniaturization requires advanced integration technologies like CMOS integrated circuits or heterogeneous integration of CMOS, MEMS, and/or flexible technologies. Connectivity requires low power RF wireless communication technologies. Humanization of biomedical devices requires design considerations from patients and clinical experiences. Data security requires more hardware and software tools to support medical data security in RF transmission and storage. Reliability requires enforcement of regulations and standards. All the leading technologies to meet the major trends will be described.

The general architecture of a biomedical electronic system may include microsystems, biomaterials, packaging/integration, and biotic-abiotic interface. A microsystem may consist of sensors/actuators, bio-signal processing units, power harvesting and management unit, and/or RF communication units, that involves many cutting-edge research topics. The research of biomaterials is related to biocompatibility, biophysics, bio-adhesives and organics. Packing and integration requires technologies in high-density interconnect, flexible substrates, inert coating, and thin-film polymers. Biotic-abiotic interface requires research on tissue response, neuroscience, electrophysiology, cell growth, and biomarkers. The applications of biomedical electronic systems in the treatment of intractable neurological disorders and chronic diseases, healthcare, telemedicine, preventive medicine, etc. will also be addressed.

As demonstrative examples, two biomedical electronic systems will be presented. One is the sub-retinal implantation system for visual prostheses and the other is close-loop deep brain stimulation (DBS) system for epilepsy. The sub-retinal implantation system includes intraocular and extraocular units. The former contains photo-sensors and electrodes for optical receiver and stimulation, and the latter one is equipped with processor and optical transmitter. Successful ERG signal recorded after the implantation indicated that the method is promising. A divisional power supply technique enabling three times larger the output stimulating current is also proposed to solve limited power supply problem.

The DBS system consists of intraocular chips with sensors/stimulators, bio-signal processing, RF transceiver, and inductive power unit and extraocular part with RF transceiver and inductive coils. The system detects patient's EEG and automatically generates DBS electrical pulses to suppress epilepsy.

Finally, some research challenges and future development of biomedical electronics will be presented and discussed.

Biography of Speaker

Dr. Peter (Chung-Yu) Wu (1998 IEEE Fellow) is President/Chair Professor of National Chiao Tung University. He served as Vice President for Conferences in 2004 -2005, and was a Board of Governor (BoG) member in 2003 in IEEE Circuit and System (CAS) Society. He was General Chair of 1994 IEEE APCCAS Conference. Dr. Wu served as Guest Editors of November 2003 Nanoelectronics Special Issue for the Proceedings of the IEEE and Aug. 1997 Multimedia Special Issue for IEEE Trans on CSVT, as Associate Editor for Trans. on CAS-Part II, Trans. on VLSI Systems, and Trans. on Multimedia. He served as CAS Editor for IEEE Circuits and Devices Magazine in 2006. Dr. Wu is the founding Chair of Technical Committee on Nanoelectronics and Giga-scale Systems. He served as Chair of Neural Technical Committee and as Chair of Multimedia Technical Committee. In regional activities area, Dr. Wu served as CAS Taipei Chapter Chair, and IEEE Taipei Section Chair. In 2000-2001, Dr. Wu served as a Distinguished Lecturer in IEEE CAS Society. Currently, Dr. Wu serves as the President of Taiwan Engineering Medicine & Biology Association (TWEMBA) promoting biomedical device and biomedical electronics research and development. He is the Director General of National Program on System-on-Chip and the President of Global Talentrepreneur Innovation & Collaboration (Global TIC) Association. The major research interest of Dr. Wu is in the area of nanoelectronic circuits and systems for implantable medical devices such as retinal prosthesis, prosthesis for epilepsy, etc.

Dr. Wu is a recipient of **IEEE Third Millennium Medal,** a **Fellow of IEEE,** and also a U.S. Fulbright Scholar. He is a member of Eta Kappa Nu and Phi Tau Phi Honorary Scholastic Societies. He served as a Visiting Professor in fall 2003 and as Adjunct International Professor since 2004 for the ECE Department at University of Illinois at Urbana-Champaign.