Bio-resorbable sensors and MEMS energy harvesters for next-generation transient and self-powered implants

Implantable medical devices and the concept of integrating sensors/electronics into the human body have been intriguing curiosities especially in medicine for many decades. Recent developments in microfabrication and materials science finally have enabled development of sub-mm-sized implants for monitoring of critical parameters such as blood pressure for heart arrhythmia, pH for GI tract complications, and neural activity for prosthetic applications. However, such devices have energy related problems so that patients need to go through a risky surgery for battery replacement periodically. This talk will cover potential approaches to eliminate this problem and realize next-generation transient/self-powered implants by utilizing bio-resorbable materials or energy harvesting microsystems.

In the first part of the seminar, a bio-resorbable and battery-free implant for wireless artery pulse monitoring will be presented. Design and fabrication of the proposed implant will be detailed by emphasizing particular diseases and surgical operations that require short-term vascular monitoring. Then, the focus will be on energy harvesting implants which can generate electrical energy within the human body for long-term implants. Widely used neural and cochlear implants increase the quality of life of patients considerably by giving them the ability to move freely and hear. However, because of their power requirement, neural implant users must undergo surgery every 2-3 years just for battery replacement, and cochlear implant users need to change battery at least twice a day. Implantable micro-electro-mechanical systems (MEMS) energy harvesters can help to reduce or eliminate the battery replacement problem. In the second part of the seminar, harvesting cerebrospinal fluid (CSF) flow pressure fluctuations within lateral ventricles of the brain using an aluminum nitride-based piezoelectric-MEMS harvester will be detailed. Concentric ring-boss diaphragm type harvester design will be introduced, and fabrication and characterization results will be presented. In addition to the MEMS-based harvester, studies on a PVDF-based flexible energy harvester array will also be presented. Then, in the final part, converting eardrum vibrations to electrical signals to stimulate auditory nerves inside cochlea using a PZT/Si cantilever-type resonant harvester to realize a self-powered cochlear implant will be discussed briefly.

Bio

Levent Beker received B.Sc. and M.Sc. degrees in Mechanical Engineering and Micro/Nanotechnology from Middle East Technical University in 2010 and 2013, respectively. During his master's he worked on fully-implantable cochlear implants. Then, he obtained his Ph.D. in Mechanical Engineering from University of California, Berkeley in 2017 where he worked on energy harvesting from cerebrospinal fluid (CSF) flow inside the brain and pressure sensors for harsh environment applications. He is currently a post-doctoral research fellow working with Professor Zhenan Bao in Chemical Engineering at Stanford University. His current research focuses on bio-resorbable wireless implants, flexible/stretchable sensors for electronic-skin applications. He received Postdocs at the Interface award from Stanford University, Howard Hughes Medical Institute (HHMI) International Researcher Fellowship, Best poster award at Berkeley Sensor Actuator Center's Industry Advisory Board Conference, Outstanding presentation award at Transducers 2013 Barcelona, and Best Thesis award from Middle East Technical University.