ES3: Wearable Wellness Devices: Fashion, Health, and Informatics



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Imagine using the same device for fashion/style and for monitoring your wellness? What about a tattoo of your child's name that also tracks your fitness and activity level. Can we make contact lenses that can change the color of your eyes but also see the calorie content of your lunch box?

Early prototypes of such devices are already emerging. Smart contact lenses can display words or images in your line of sight, and stretchable/tattoo electronics can monitor vital signs. However, there are significant design and technology challenges ahead to actually make these devices fully functional, autonomous, and reliable.

Let's hear from the experts what could be the future of wearable wellness devices and what technologies are being developed.

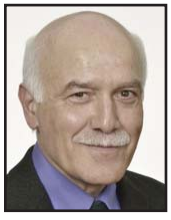
Panelist's Statements

Stretchable Electronics: Biointegrated Systems with Unusual Materials and Designs
Roozbeh Ghaffari, *MC10, Cambridge, MA*
Advances in soft biomaterials and microelectronics technologies have driven important advances in healthcare. However, there are significant mechanical and geometrical constraints inherent in all standard forms of rigid electronics. These constraints impose unique integration and therapeutic delivery challenges for noninvasive, minimally invasive and implantable medical devices. Here, we describe novel materials and design constructs for skin-based systems that incorporate physiological sensors (e.g. active electrodes, temperature sensors, and accelerometers) and therapeutic actuators configured in stretchable formats. Quantitative analyses of light diffusion, electronic/sensor performance and data transmission under mechanical stress, underpin the clinical utility of these systems in health monitoring, wellness and photomedicine. As demonstrations of this technology, we present representative examples of biointegrated systems that highlight previously unrealized functionality and performance coupled with extreme mechanical flexibility.

Smart Textiles for Wearable Electronics
Jerald Yoo, *Masdar Institute of Science and Tech, Abu Dhabi, UAE*
Smart textile that prints circuit board directly on wearable materials (e.g., natural or synthetic fabrics and textiles) will provide an ideal platform for wearable electronics such as sensing, computing, and a communication platform that can address several individual and societal needs in the areas of healthcare, lifestyle, and social networking. However, there are several design challenges including non-ideality and variability of the platform. This talk presents recent trends in smart textile and their efforts in circuit perspective to overcome these challenges. The electrical characterization of wearable electronic passives such as printed capacitors and inductors will be discussed, in which the supporting substrate is undergoing constant deformations, including stretching, wrinkling, compression and aging. Novel circuit techniques to compensate such non-idealities will be presented. We will also cover system examples.

Extremely Low-Power Circuit Design for Wearable Systems
Makoto Takamiya, *University of Tokyo, Tokyo, Japan*
In order to expand the use of wearable wellness devices, maintenance-free and wearing-unconscious devices are required. Extremely low power circuits and autonomous energy delivery systems are required for maintenance-free devices. Ultra-flexible or ultra-small-size devices are required so the user is ultimately not conscious of wearing the devices. This talk will cover (1) a sub-100mW 0.5-V RF transceiver for body area networks and power management circuits, (2) an 80mV input boost converter for thermoelectric energy harvesting, and (3) a "not conscious of wearing" surface electromyogram measurement sheet with 2V organic transistors on an ultra flexible 1mm thickness PEN film for a prosthetic hand control. Finally, future technical challenges of wearable wellness devices will be discussed.

Smart Contact Lenses and Integrated Circuits
Jelle De Smet, *Ghent University, Ghent, Belgium*
Contact lenses are widely used as a passive tool for ophthalmic corrections. Smart contact lenses go beyond their classic counterparts, having applications in augmented reality, biomedical sensing and active vision correction. This increased functionality encompasses the integration of electronic components such as RF antennas, IC chips, solar cells, sensors and electro-optic elements. A brief overview is given of this new research field and the challenges concerning IC design are presented. Amongst others, these include maximum die size, mechanical properties, power consumption and cost.



Energy Harvesting for Wearable Systems
Yiannos Manoli, *University of Freiburg and HSG-IMIT, Freiburg, Germany*
Energy Harvesting has established itself as a method of extracting energy from the environment such as light, vibration, thermal gradients or electrochemical reactions. Extending these concepts from the technical domain of machines, cars or appliances to the human body confronts the designer with a number of challenges: human actions provide only very small motions of low and non-resonant frequencies and photovoltaic or thermoelectric methods can be applied only under very demanding conditions.

These power sources deliver low levels of usable energy, thus any system will have to seek ways to maximize the effectiveness. Each transduction principle that converts the available energy to electrical power requires a different circuit technique for achieving an optimal conversion. Such an adaptive control has to be intelligent enough to always find the optimum without requiring too much energy. Here lies a major challenge for low-power and low-voltage electronics.