Imperceptible sensor foils for soft electronics and machines

Martin Kaltenbrunner(martin.kaltenbrunner@jku.at)
Department of Soft Matter Physics / LIT Soft Materials Laboratory, Johannes Kepler University Linz, Altenberger Str. 69, 4040 Linz, Austria

Abstract

Electronics of tomorrow will be imperceptible and will form a seamless link between soft, living beings and the digital world. Exploring the fundamental physics, mechanical form factors, and materials required to meet the needs of this new generation of soft electronics and soft machines is driving multidisciplinary research worldwide. Weight, flexibility and conformability are pivotal for future wearable, soft and stretchable electronics to proliferate. The abilities to be imperceptible, epidermal, transient and self-healing are fueling the vision of autonomous smart appliances to be embedded everywhere, on textiles, on our skin, and even in our body.

This talk introduces a technology platform for the development of large-area, ultrathin and lightweight electronic and photonic devices, including solar cells, light emitting diodes and photodetectors, active-matrix touch panels, implantable organic electronics, imperceptible electronic wraps and "sixth-sense" magnetoception in electronic skins. Air stable perovskite solar cells, only 3 μm thick, endure extreme mechanical deformation and have an unprecedented power output per weight of 23 W/g. Highly flexible, stretchable organic light emitting diodes are combined with photodetectors for on-skin photonics and pulse oximetry, providing electrical functionality in yet unexplored ways. Tactile sensor arrays based on active-matrix organic thin film transistors can be operated at elevated temperatures and in aqueous environments as an imperceptible sensing system that ensures the smallest possible discomfort for patients requiring medical care and monitoring. Combined with organic amplifiers and biocompatible conductive gels, we demonstrate *in vivo* recording of vital signals. E-skins with GMR-based magnetic field sensors equip the wearer with an unfamiliar sense that enables perceiving of and navigating in magnetic fields. These large area sensor networks build the framework for electronic foils and artificial sensor skins that are not only highly flexible but become highly stretchable and deployable when combined with engineered soft substrates such as elastomers, shape memory polymers or hydrogels. We show mobile health monitoring systems, smart, tissue-like electronics and soft robots that utilize tough hydrogels as soft transducers, generators and adaptive lenses. A newly developed direct writing method for ultrathin oxide dielectrics and semiconductors will allow low-cost and large area fabrication of such soft systems.

Tackling issues of sustainability and resourceful production, we here introduce materials and methods for soft systems that facilitate a broad range of applications, from transient wearable electronics to metabolizable soft robots. These embodiments are reversibly stretchable, are able to heal and are resistant to dehydration. Our forms of soft electronics and robots – built from resilient biogels with tunable mechanical properties – are designed for prolonged operation in ambient conditions without fatigue, but fully degrade after use through biological triggers. Electronic skins merged with imperceptible foil technologies provide sensory feedback such as pressure, strain, temperature and humidity sensing in combination with untethered data processing and communication through a recyclable on-board computation unit. Such advances in the synthesis of biodegradable, mechanically tough and stable iono-and hydrogels may bring bionic soft systems a step closer to nature.

Biography

Kaltenbrunner is a full professor at the Johannes Kepler University, heading the Soft Matter Physics Department and the LIT Soft Materials Laboratory. He received his master's and PhD degrees in physics from the Johannes Kepler University in 2008 and 2012, respectively. Kaltenbrunner's research interests include soft electronics and machines, biodegradable soft materials, photovoltaics, lightning and thin film transistors, soft transducers and robotics, flexible and stretchable electronics.