IEEE FLEPS 2023

IEEE International Conference on Flexible, Printable Sensors and Systems

Boston, Massachusetts, USA // July 9-12, 2023

FLEPS 2023 CONFERENCE PROGRAM

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MESSAGE FROM THE CONFERENCE CHAIRS

Dear Colleagues and Friends,

It is our pleasure to welcome you to the 5th IEEE International Conference on Flexible Printable Sensors and Systems (FLEPS 2023) at Northeastern University in Boston. After the resounding success of in-person FLEPS in Vienna last year, it is not only our honor and pleasure to continue the tradition, but we are also delighted to be celebrating the 25th anniversary of the founding of IEEE Sensors Council this year. We are thankful to IEEE Sensors Council for sponsoring and the continued support of the conference by helping us in bringing together and growing a strong community of researchers and industry partners in the area of flexible electronics and printed sensors and systems.

The IEEE FLEPS Conference is exclusively dedicated to flexible, printable and large-area sensors and electronics technologies and their applications. IEEE FLEPS offers an excellent forum to discuss the latest developments in the field and shape the future roadmaps for electronics based on non-conventional materials and manufacturing technologies. IEEE FLEPS 2023 offers a unique opportunity for the academic community to meet and network with industry leaders in the field, and for industry to get an update on the latest advances and challenges in this field. To this end, this year the conference will have the first half of the day dedicated to talks by industry experts on Tuesday July 11, 2023. This is further enriched by the exhibitors and lab tours. We hope the atmosphere, the breadth and the depth of research topics combined with the quality of invited and contributed technical presentations will make IEEE FLEPS a compelling event from which you are unable to stay away in the future years.

The conference technical program consists of about 150 technical presentations over three full days, and follows the tutorial sessions organized on Sunday July 9, 2023. The 5 tutorials offered, this year are: Approaches for Scalable and Self-Healing Hybrid Electronic Materials, Bioinspired In-Sensor Computing, Flexible and Stretchable Inorganic Solar Cells for Wide Ranging Deployment, E-Tattoos – Materials, Design, Manufacturing, Functionalities, and Applications, and Hybrid Printing and Laser Patterning Strategies for Wearable and Implantable Biochemical Sensors. Each day will have a plenary talk by a speaker of world-renowned fame who will provide comprehensive overview of the most interesting advances, challenges, and opportunities to uniquely position this conference in the field. Our oral sessions start with an invited talk by a leading expert on the topic and will be followed by talks based on contributed papers selected by the Technical Program Committee after the peer review process. The contributed papers will be presented in oral and poster formats.

This year FLEPS conference also has 7 new focused sessions on topics aiming at the latest developments in flexible, printable, large- area sensors and systems enabling applications in the next generation sensors and electronics systems. The 7 focused sessions are: Printed Sensors & Devices for Bioelectronics & Digital Health, Flexible Devices for Metal Halide Perovskites, Wearable Theranostic Devices, Sensors for Sustainable Digital Agriculture, Flexible Sensory Systems & Human Machine Interfaces for Robotic Applications, Intelligent Soft Machines Merging Flexible Sensors & Soft Actuators, and Fiber Based Soft Sensors and Devices for Wearable and Bioelectronics. These sessions reflect some of the emerging areas in flexible and printed systems, not covered by regular tracks and we plan to continue exploring such emerging topics in future editions of FLEPS.

MESSAGE FROM THE CONFERENCE CHAIRS

The Digest of Technical Papers for the IEEE FLEPS 2023 contains three-page versions of papers, provided by the contributing and invited authors in an electronic form. This year, we provided authors with the option to submit papers to IEEE Sensors Letters Journal which were then reviewed by journal and further discussed by TPC meeting for inclusion into the conference program. We have a dedicated track for these papers and a total of 19 papers were accepted into the conference through IEEE Sensors Letters route. All presented papers will be available in the IEEE Xplore as Conference Proceeding or as IEEE Sensors Letters articles. The conference proceedings will have the DOI of IEEE Sensors Letters papers so that they can be directly viewed and read from the journal site. This avoids duplicate publication, a requirement of IEEE publications. Furthermore, there is also the provision to record the presentations, with presenters' consent. All recorded presentations will be posted online via IEEE Sensor Council's YouTube channel for wider dissemination of the research work presented during the conference. Authors presenting at IEEE FLEPS 2023 will also have the opportunity to submit the extended versions of their conference papers to the Special Journal Issue in IEEE Journal on Flexible Electronics (J-FLEX).

The Awards Committee will select 3 Best Student Papers from about 10 finalists. The finalists will be selected by awards co-chairs from a list of candidates recommended by the track co-chairs based on the quality and scores received from peer review process. The finalists also get an opportunity to pitch their works to awards committee, which comprises of awards co-chairs and some members of the technical program and organizing committee. We would like to congratulate all the finalists and wish them good luck!

The conference is being held in the state-of-the art Interdisciplinary Science and Engineering Center at Northeastern University in the heart of Boston. The reception on Sunday July 9, 2023 will be held on the 17th floor of East Village on the campus from where you can have excellent views of the city of Boston. We strongly encourage you to plan to attend this event. As part of the 25th Anniversary Celebrations we have assembled a panel of experts to discuss sustainable approaches to flexible sensors and electronics. Following the sustainability panel, we will have gala dinner at the Museum of Fine Arts which is about 10-minute walk from the conference venue. The Museum of Fine Arts in Boston is having an exposition of Hokusai's art and influence which we also strongly recommend you to see. From coffee and lunch breaks amongst posters and exhibitors, to all the social events, we hope you will find ample possibilities for stimulating discussions, meeting old friends and making new ones, and having a great time at IEEE FLEPS 2023.

We would like to express our special thanks to the Technical Program Committee and track co-chairs who contributed their time to evaluate submissions, and to the Steering Committee, who provided guidance towards the conference organization and strategic planning.

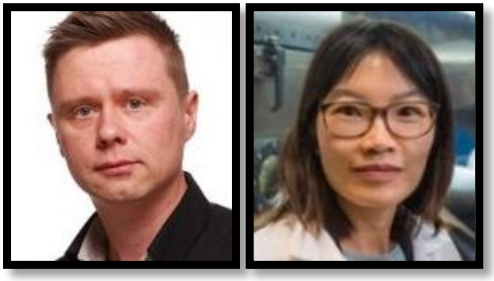
We want to thank our sponsors for their support. Our Gold Patron, Nano Dimension, Silver Patron, Neotech AMT and Exhibitors, XTPL and Northeastern University for hosting us.

We thank the IEEE Sensors Council for sponsoring the IEEE FLEPS 2023 as well as our Patrons and Exhibitors. Our special thanks to Claire Folkerts, at Conference Catalysts, LLC, for administrative support.

MESSAGE FROM THE CONFERENCE CHAIRS

Finally, we thank all speakers, presenters, and attendees for making IEEE FLEPS 2023 such a unique event. We hope that you find FLEPS 2023 professionally stimulating and enjoyable, and of course, we are looking forward to seeing you back next year for the FLEPS 2024 in Tampere, Finland.

Luisa Torsi and Srinivas Tadigadapa, IEEE FLEPS 2023 General Co-Chairs



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Track 4: Bio- and Chemical Sensors
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Track 5: Energy Harvesting and Storage
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Track 7: Hybrid Integrated Systems, Thin Chips and Packaging
Muhammad Hussain, *Purdue University, USA*
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Track 8: Reliability, Simulation, and Modeling
Massood Atasbar, *Western Michigan University, USA*
Jasmin Aghassi, *Karlsruhe Institute of Technology, Germany*

Track 9: Printed Smart Tags and Communication Devices
Shweta Agarwala, *Arhus University, Denmark*
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Track 10: Emerging Applications
Nanshu Lu, *University of Texas, Austin, USA*
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Focused Session 1: Printed Sensors and Devices for Bioelectronics and Digital Health
Hongki Kang, *Daegu Gyeongbuk Institute of Science and Technology (DGIST), South Korea*
Gerd Grau, *York University, Canada*
Yasser Khan, *University of Southern California, USA*

Focused Session 3: Wearable Theranostic Devices
Yangzhi Zhu, *Terasaki Institute for Biomedical Innovation, USA*
Wujin Sun, *Virginia Tech, USA*

Focused Session 4: Sensors for Sustainable Digital Agriculture
Sofia Sandhu, *University of Glasgow, Glasgow, UK*
Maria Smolander, *VTT Technical Research Centre of Finland, Finland*

Focused Session 5: Flexible Sensory Systems and Human-Machine Interfaces for Robotic Application
Mitradip Bhattacharjee, *Indian Institute of Science Education and Research, Bhopal, India*
Gerd Grau, *York University, Canada*
Oliver Ozioko, *University of Derby, UK*

Focused Session 6: Intelligent Soft Machines Merging Flexible Sensors and Soft Actuators
Xiaoguang Dong, *Vanderbilt University, USA*
Yue Gu, *Yale University, USA*
Haisong Lin, *Hongkong University, China*

Focused Session 7: Fiber-Based Soft Sensors and Devices for Wearable and Bioelectronics
Jaehong Lee, *Daegu Gyeongbuk Institute of Science and Technology (DGIST), South Korea*
Taeyoon Lee, *Yonsei University, South Korea*

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PLENARY SPEAKERS

Soft Bioelectronics: Design Concepts for Engineered Elasticity
Stephanie Lacour
EPFL, Switzerland

The introduction of soft materials and microtechnology provides an opportunity to engineer bioelectronic systems with mechanical compliance. Inorganic thin films of electronic materials are integrated with polymeric carrier structures using standard fabrication techniques. Elastomers provide the soft, outer envelope of the system. Geometrical designs with controlled curvature and features across scales enable programmable deformations in one or multiple axis combined with electrical performance. This talk will report on our methodical approach to design, manufacture and test soft bioelectronics with engineered elasticity. Designs from lab-based to implantable translational bioelectronics will be showcased.

Flexible Electronics: Challenges and Opportunities — a Materials Science View
Natalie Stingelin
Georgia Institute of Technology and School of School of Materials Science & Engineering, USA

In recent years, immense efforts in the flexible electronics field have led to unprecedented progress and to devices of ever-increasing performance. Despite these advances, new opportunities are sought in order to widen the applications of organic-based technologies and expand their functionalities and features. We discuss here challenges and opportunities, with focus on the use of multicomponent systems for, e.g., increasing the mechanical flexibility and stability of organic electronic products, or introducing other features such as self-encapsulation and faster mixed ion-electron transport. One specific strategy is based on blending polymeric insulators with organic semiconductors; which has led to a desired improvement of the mechanical properties of organic devices, producing in certain scenarios robust and stable architectures. Here we discuss the working principle of semiconductor:insulator blends, examining the different approaches that have recently been reported in literature. We illustrate how organic field-effect transistors (OFET)s and organic solar cells (OPV)s can be fabricated with such systems without detrimental effects on the resulting device characteristics even at high contents of the insulator. Furthermore, we review how blending can assist in the fabrication of more reliable and versatile organic electrochemical transistors (OECT)s.

Electrophoretic Display Technology for Ultra-low Power Smart and Green Switching Surfaces
Edzer Huitema
E Ink Corporation, USA

Reflective displays are ideal for low-power applications. Electrophoretic displays are reflective displays that use pigment systems similar to ink-jet printing on paper to create a paper-like viewing experience. Besides being reflective, Electrophoretic displays have the unique characteristic of retaining its last image even when powered down, making it the lowest power reflective display technology. It is now becoming the dominant reflective display technology that can be found in products ranging from eReaders, signage, transport, industrial and automotive. This talk will cover the latest developments in Electrophoretic displays, its characteristics and application areas.

INVITED SPEAKERS

Graphene-Based Rapid, Multiplexed, Easy, and Cheap Sensing for Personalized Medicine and Epidemiology
Ken Burch
Laboratory for Assembly and Spectroscopy of Emergence, Boston College, USA

I will outline our group's newly developed Graphene Electronic Multiplexed Sensors (GEMS) platform. The device is the size of a penny and can be easily functionalized to sense four different analytes at the same time. The platform detects the presence of analytes attached to the graphene (single layer of carbon) electrically, with limits of detection relevant to clinical settings. It can be easily operated and is robust against different environments. I will discuss our demonstrations of its use for detecting antibiotic-resistant bacteria, decease biomarkers in saliva, and opioids in wastewater.

Soft Electronics with a Noise-Free Hydrogel Damper
Tae-il Kim
Sungkyunkwan University (SKKU), Korea

Bioelectronics needs to continuously monitor mechanical and electrophysiological signals for patients. However, the signals always include artifacts by patients' unexpected movement (such as walking and respiration under approximately 30 hertz). The current method to remove them is a signal process that uses a bandpass filter, which may cause signal loss. We present an unconventional bandpass filter material—viscoelastic gelatin-chitosan hydrogel damper, inspired by the viscoelastic cuticular pad in a spider—to remove dynamic mechanical noise artifacts selectively. The hydrogel exhibits frequency-dependent phase transition that results in a rubbery state that damps low-frequency noise and a glassy state that transmits the desired high-frequency signals. It serves as an adaptable passfilter that enables the acquisition of high-quality signals from patients while minimizing signal process for advanced bioelectronics.

OLED-Based Infrared-to-Visible up-Conversion Devices
Do Young Kim
Oklahoma State University, USA

The ability to harvest & convert energy over a wide band of the light spectrum, which includes visible and infrared, has tremendous value. Silicon-based photodetectors have currently become the mainstream technology. However, solution-processable photoactive materials such as halide perovskites and polymers with excellent photosensitivity, bandgap tunability, and solution processability provide an attractive material system to realize such inexpensive photodetectors.I I will first discuss recent progress in my research employing various solution-processable low-bandgap materials including halide perovskites as well as organic semiconductors with light absorption by around 1000 nm, which is similar to Si for alternative low-cost photodetector applications. I will then describe our efforts to investigate a novel infrared sensitive organic light emitting diode (OLED) as an alternative technology for infrared imaging, functioning as an infrared-to-visible up-conversion device, with various cost-effective infrared sensitizers such as PbS colloidal quantim dots (CQDs), low-bandgap small molecules and polymers, and hybrid halide perovskites. The OLED-based infrared-to-visible up-conversion devices have a similar structure compared with conventional OLEDs. The key to up-conversion device is to keep the device in the off-state even if a forward bias is applied to it and to turn-on the device only when there is incident infrared light. I believe these works will lead to a paradigm shift in the future imaging technology and is of great interest to the general scientific community.

INVITED SPEAKERS

The Future of Cardiac Biomarker Sensing using gFET Technology
Sabine Szunerits
University of Lille, France

Cardiovascular diseases (CVDs) remain one of the leading causes of death worldwide. To improve therapeutic outcomes and reduce health care costs, a better understanding of disease-specific variation across cardiac patients is needed. Emerging technologies provide opportunities for patients with cardiovascular problems in the form of home diagnosis and therapy. Biosensors are increasingly viewed as appealing alternatives to expensive analytical techniques in the health care industry, with electrical biosensors being especially promising when interconnected with 2D materials such as graphene. Despite impressive achievements in the electrical performance of graphene-based field effect transistors (gFET), some key bottlenecks need to be tackled: reproducibility of gFET preparation, maintaining high mobility after surface modification and sensing in high ionic strength medium. In this talk I will focus on some of our recent works on DNA and PNA aptamer modified graphene-based FETs (GFETs) for cTnI and pro-NT-BNP diagnostics in serum as well as exhaled breath condensate (EBC) samples.

Material and Device Designs in Biomimetic Polymer Electronics
Sihong Wang
Pritzker School of Molecular Engineering, The University of Chicago, IL, USA

The vast amount of biological mysteries and biomedical challenges faced by humans provide a prominent drive for seamlessly merging electronics with biological living systems (e.g. human bodies) to achieve long-term stable functions. Towards this trend, one of the key requirements for electronics is to possess biomimetic form factors in various aspects for achieving long-term biocompatibility. To enable such paradigm-shifting requirements, polymer-based electronics are uniquely promising for combining advanced electronic functionalities with biomimetic properties. In this talk, I will introduce our new molecular-design, chemical-synthesis, and physical-processing concepts for polymer semiconductors, which enabled the incorporation of multiple biomimetic properties with advanced electronic and photonic functionalities. Furthermore, enabled by these new materials, we have also created new device designs and fabrication processes for building unprecedented functional devices, including stretchable and bioadhesive biosensors, stretchable neuromorphic devices, and stretchable OLEDs, which all simultaneously achieve high performance and new biomimetic properties. Collectively, our research is opening up a new generation of electronics that fundamentally changes the way that humans interact with electronics.

Photodetectors and solar cells for robotics and wearable electronics
Jean-Michel Nunzi
Queens University, Canada

Owing to their solution processing, lightweight wearable, power conversion efficiency, ready to deploy for extreme lightweight space, and reduced cost of constituent materials, perovskite solar cells have received interest in the recent years. High-quality perovskite films obtained by low-temperature fabrication methods and the development of appropriate interface and electrode materials propelled the efficiency of perovskite solar cells to 26% efficiency, with some margin for further improvement. Perovskite solar cells' stabilization has also become an intense field of research, together with cost reduction. In the meantime, photodetectors were developed to cover the needs for enhanced robotics' vision and free-space optical communications.

INVITED SPEAKERS

Novel Metal-Mesh Transparent Conductors for Flexible and Stretchable Electronics Applications
Zheng Cui
Jiangsu Industrial Technology Research Institute (JITRI), China

Transparent conductors are not only the key component in touch panels but required for a wide spectrum of other applications. Indium-tin-oxide (ITO), which is the most industrialized transparent conductive materials, is not suitable for flexible electronics. Many alternatives have been developed such as carbon nanotubes, silver nanowires, graphene and metal-mesh. The speaker's group developed a unique way of making transparent conductors by embedding conductive inks into imprinted grooves to form a metal-mesh, which enables extremely high conductivity (0.03ohm/sq.) while still maintains high optical transparency (86%) and high flexibility. Since developed, the embedded metal-mesh transparent conductors have been successfully applied to commercial touch panels, transparent electromagnetic shielding, heating films and thermotherapeutic patch for cancel healing. The talk will focus on recent development of the metal-mesh as stretchable transparent conductors and application in stretchable electroluminescent devices.

Finding an Experimentally Validated 2D Model of Organic Electrochemical Transistors
Björn Lüssem
University of Bremen, Germany

Organic Electrochemical Transistors are seen as a key element for a fully flexible and wearable sensor technology. To systematically discuss trends in OECT experiments and to numerically optimize OECT performance, an experimentally validated device model is needed. Here, first steps towards such a model are described. A focus is put on a correct description of the steady-state and transient switching observed in OECTs.

Flexible Wireless Systems for E-Textiles
Steve Beeby
School of Electronics and Computer Science, University of Southampton, UK

Wireless systems are an essential component for autonomous electronic textile (e-textile) applications for both communications and the supply of power. Textiles provide a ubiquitous platform for wearable applications but their application goes far beyond clothing and they are also widely used in, for example, industry, civil engineering, agriculture and the marine environment. The mechanical properties of textiles relating to strength, robustness, flexibility and comfort mean electronic systems have to be carefully engineered to avoid negatively impacting these properties and survive the rigours of use. This talk will provide an overview of flexible RF and resonant inductive coupled wireless systems developed for e-textiles applications. A range of scalable textile industry-compatible fabrication processes including solution processing and automated embroidery have been used to realise a wide range of flexible rectennas, coils and RFID tags. The talk will present examples of rectennas for energy harvesting, simultaneous wireless information and power transfer, sensing and inductive power transfer and provide example applications and use case scenarios.

INVITED SPEAKERS

Integrated Soft Materials for Human-Compatible Machines & Electronics
Carmel Majidi
Carnegie Mellon University, USA

Progress in soft lithography and soft materials integration have led to extraordinary new classes of soft-matter sensors, circuits, and transducers. These material technologies are composed almost entirely out of soft matter – elastomers, gels, and conductive fluids like liquid metal – and represent the building blocks for machines and electronics that are soft, flexible, and stretchable. Because of their intrinsic compliance and elasticity, such devices can be incorporated into soft, biologically-inspired robots or be worn on the body and operate continuously without impairing natural body motion. In this talk, I will review recent contributions from my research group in creating soft multifunctional materials for wearable electronics and soft robotics using these emerging practices in "soft-matter engineering." In particular, I will focus on soft robotic systems powered using shape memory materials and soft material architectures for highly stretchable digital electronics, wearable energy harvesting, and electrically-responsive actuation. When possible, I will show how the design and operation of these soft-matter technologies can be guided by theoretical models based on underlying principles of mechanics and material science. In addition to presenting my own research in the field, I will also briefly review broader efforts and emerging challenges in utilizing soft multifunctional materials for applications in wearable electronics, bioelectronic interfaces, and soft robotics.

Direct Writing of Elastic Conductors for Three-dimensional Skin-mountable Electronics
Seungjun Chung
Korea Institute of Science and Technology & Korea University, South Korea

Printing technologies have attracted tremendous attention in the realization of customized soft electronics due to their advantages, such as non-vacuum, low-temperature, and non-contact processability. In this presentation, I would like to present our recent results of printing solid-state elastic conductors into self-supporting three-dimensional (3D) geometries that promise the design diversity of soft electronics, enabling complex, multifunctional, and tailored human-machine interfaces. Our omnidirectional printing strategies achieve superior viscoelastic properties that provide the structural integrity of printed features, and pseudoplastic and lubrication behaviors that allow great printing stability simultaneously. Freestanding, filamentary, and out-of-plane 3D geometries of intrinsically stretchable conductors are directly written, achieving a minimum feature size <100 μm and excellent stretchability >150%. Particularly, the evaporation of the continuous phase in the emulsion results in microstructured, surface-localized conductive networks, significantly improving their electrical conductivity. To illustrate the feasibility of our approach, we demonstrate skin-mountable electronics that visualize temperature on a matrix-type stretchable display based on omnidirectionally printed elastic interconnects.

INVITED SPEAKERS

Fabrication and use of Microneedle Equipped Devices for Wound Healing Applications
Ali Tamayol
University of Connecticut Health Center, USA

Most skin injuries heal by tissue regeneration and repair. However, in patients with underlying conditions such as diabetes or with vast injuries, healing may be impaired. Impaired wound healing has been responsible for significant financial burden, pain, morbidity, and mortality. The focus in wound healing has been on the therapeutics that target one or multiple (patho)physiologies. Also, there has been an emphasis on controlling the temporal release of those drugs. Recently, our group and others demonstrated that the point of delivery of therapeutics could be another factor that could significantly change biological outcome. We demonstrated that microneedle-mediate delivery of therapeutics enhances their effectiveness. In this presentation, we will discuss the engineering of our fully automated microneedle-equipped dressing for precise dosing of different drugs and will demonstrate the benefit of intralesional delivery on therapy outcome. We created bilayer micromaterial microneedles that allows the engineering of structures that can penetrate regardless of the material properties and control spatiotemporal drug distribution. We fabricated microneedles with dissolvable backing for the programmable delivery of anti-inflammatory therapeutics. The results showed the benefit of this strategy in healing of chemically challenged wounds. We have also developed strategies for the fabrication of hollow microneedles from biocompatible materials allowing both active and passive drug delivery.

Wireless Smart Bandage with Integrated Sensors and Stimulators for Advanced Wound Care and Accelerated Healing
Yuanwen Jiang
University of Pennsylvania, USA

Chronic nonhealing wounds represent a substantial healthcare burden, with >6 million individuals affected in the United States alone. A chronic wound is defined as one that has failed to heal by 8–12 weeks and is unable to restore function and anatomical integrity to the affected site. These wounds are associated with loss of function and mobility, increased social stress and isolation, depression and anxiety, prolonged hospitalization and overall increased morbidity and mortality. In addition, the financial cost to the healthcare system for the management of chronic wound-related complications has been estimated at >US$25 billion annually. ‘Smart’ bandages based on multimodal wearable devices could enable real-time physiological monitoring and active intervention to promote healing of chronic wounds. However, there has been limited development in incorporation of both sensors and stimulators for the current smart bandage technologies. Additionally, while adhesive electrodes are essential for robust signal transduction, detachment of existing adhesive dressings can lead to secondary damage to delicate wound tissues without switchable adhesion. Here, we overcome these issues by developing a flexible bioelectronic system consisting of wirelessly powered, closed-loop sensing and stimulation circuits with skin-interfacing hydrogel electrodes capable of on-demand adhesion and detachment. In mice, we demonstrate that our wound care system can continuously monitor skin impedance and temperature and deliver electrical stimulation in response to the wound environment. Across preclinical wound models, the treatment group healed ~25% more rapidly and with ~50% enhancement in dermal remodeling compared with control. Further, we observed activation of proregenerative genes in monocyte and macrophage cell populations, which may enhance tissue regeneration, neovascularization, and dermal recovery.

INVITED SPEAKERS

All-Carbon Nanomaterial Inks for Print-In-Place, Recyclable, and Water-Based Electronics

Aaron Franklin
Duke Pratt School of Engineering, North Carolina, USA

For decades we've been hearing about the promise of printing electronics directly onto any surface. However, despite significant progress in the development of inks and printing processes, reports on fully, direct-write printed electronics continue to rely on excessive thermal treatments and/or fabrication processes that are external from the printer. In this talk, recent progress towards print-in-place electronics will be discussed; print-in-place involves loading a substrate into a printer, printing all needed layers, then removing the substrate with electronic devices immediately ready to test. A key component of these print-in-place transistors is the use of inks from various nanomaterials, including: 2D graphene and hexagonal boron nitride, and 1D carbon nanotubes. Using an aerosol jet printer, these mixed-dimensional inks are printed into functional 1D-2D thin-film transistors (TFTs) without ever removing the substrate from the printer and using a maximum process temperature of 80 ºC with most processing occurring at room temperature. Using a similar print-in-place process, completely recyclable printed transistors will be discussed, fabricated entirely using nanoscale carbon-based inks. These recyclable devices exploit a printed crystalline nanocellulose (CNC) ionic dielectric. Finally, the same set of carbon-based inks will be demonstrated for use in all-aqueous (completely water-based) printed CNT-TFTs, eliminating dependence on processing with hazardous chemicals. These demonstrations give evidence for an electronic future involving devices with fabrication and/or function that goes beyond what is possible with traditional semiconductor technologies. The increasingly prolific distribution of sensing devices will best be served by using more environmentally friendly materials and fabrication processes, which this work provides a vision for achieving.

INVITED SPEAKERS

Sensors for Sustainable Digital Agriculture
Shane Ward
University College Dublin, Ireland

With global demand for food projected to increase by ca. 50% by mid-century, the agri-food sector must produce this food in an environmentally sustainable manner. This is particularly challenging for an industry that is highly dependent on fossil fuels and where total system losses (waste and inefficiencies) are ca. 50%. It is against this background that Digital Agriculture has a pivotal role to play in enhancing overall operational efficiency. The agri-food sector comprises several stages, a continuum, from on-farm production, through processing, retail, the consumer (citizen) and beyond into an agri-food bioeconomy. Digital Agriculture offers the opportunity to enhance overall operational efficiency of the full agri-food chain, through: (i) gathering data of the quality and scale needed to understand, manage and monitor system performance; (ii) implementing data-driven systems that are designed to optimise (or near optimise) operational efficiency (and hence resource use efficiency); (iii) providing continuous system monitoring, enabling iterative feedback-based system improvement; (iv) providing regulatory overview (monitoring) of compliance with product assurance, environmental impact regulations; (v) providing the consumer (citizen) with credible high quality, verifiable information on the provenance, quality and safety of their food; (vi) providing verification of the provenance and quality of feedstock for a sustainable agri-food based bioeconomy. While digital agriculture has the potential to integrate these features, the critical factor in delivering effective operational systems is the data – its quality, quantity, time-sensitivity, scale and availability (including cost). System variability varies from stage to stage along the agri-food continuum (pre- and post-farm gate), with pre-farm gate (viz. on-farm production) being the most variable as operations are subject to weather, geo-spatial, bio- and market (demand and price) variability. This paper discusses the range of data sources required to achieve enhanced system efficiency, their availability, capture (i.e. sensing technology, scale, costs) and integration into suitable decision support and control systems. It concludes that while several new and existing sensing technologies offer a kaleidoscope of data sources, the real challenges are addressing data quality, variability, scale; and the analyses and integration of these data to deliver effective commercially implementable models delivering enhanced operational performance, monitoring and feedback.

A Tomographic Tactile Sensing Approach for Soft Robot Skins
Hyosang Lee
University of Stuttgart, Germany

A soft and sensitive tactile skin is fundamental component of robots to perceive their surrounding environments physically. Although numerous tactile sensors have been demonstrated on a 2-D plane, a soft skin that can be integrated on complex, 3-D surface of a robot body is yet stagnated due to various fabrication challenges. Recently, a tomographic tactile sensing inspired by biological tactile perception mechanism has emerged as a promising approach to practically realize soft robot skin. This approach simplifies the tactile sensor design through computation, making it easier to integrate on a robot body. This talk introduces the fundamentals of tomographic tactile sensing and its potential in robotic skin research.

INVITED SPEAKERS

Electronically Integrated Microscopic Robots
Itai Cohen
Cornell University, USA

What would we be able to do if we could build electronically integrated machines the at a scale of 100 microns? At this scale, semiconductor devices are small enough that we could put the computational power of the spaceship Voyager onto a machine that could be injected into the body. Such robots could have on board detectors, power sources, and processors that enable them to sense, interact, and control their local environment. In this talk I will describe several cutting edge technologies we are developing to achieve this vision.

Addressing challenges in Minimally invasive Surgery through Soft Robotics
Sheila Russo
Boston University, USA

Minimally invasive surgical (MIS) procedures pose significant challenges for robots, which need to safely navigate through and manipulate delicate anatomy while performing complex tasks to treat tumors in remote areas. Soft robots hold considerable potential in MIS given their compliant nature, inherent safety, and high dexterity. Yet, a significant breakthrough of soft robots in surgery is impeded by current limitations in the design, manufacturing, and integration of soft materials that combine actuation, sensing, and control. This talk will illustrate our work towards achieving safe navigation, distal actuation, integrated sensing, and effective force transmission in MIS by highlighting different classes of soft surgical robots, i.e., soft continuum robots, soft-foldable robots, and soft reactive skins with applications in lung cancer, colorectal cancer, and brain cancer surgery.

INVITED SPEAKERS

Paper-based Wearable Biosensors and Biobatteries
Seokheun "Sean" Choi
State University of New York, Binghamton, USA

Wearable, flexible electronic devices have received tremendous attention in recent years because of their in situ and real-time monitoring capabilities of human health parameters and mobile activities in a non-invasive or minimally invasive manner. However, the immaturity of the technique for seamless and intimate integration of electronics with the human body hampers prolonged device wearing. Wearables provoke discomfort, distraction, and burden. Even with the reduced discomfort from emerging electronic skin technology, wearable devices are only suitable for short-term missions or must be replaced intermittently because of human perception of the presence of the devices. Practically, many wearable diagnostic sensors are designed for one-time or short-term applications and then thrown away. As those single-use wearables are increasingly pervasive and updated frequently, there is increasing demand for disposable, low-cost wearable platforms. Their disposability is a critical development requirement to avoid potential infections or the possible release of toxic substances after use. Paper-based device platforms offer great opportunities for single-use wearable applications because of their disposability, flexibility, biocompatibility, breathability, wickability, porosity, and low-cost. Moreover, paper's rich tunability with many other functional materials enables facile engineering and manufacturing possibilities. In particular, all-printed paper-based electronics can be readily realized with functional inks. Many paper-based flexible devices have been proposed for wearable applications with large upside potential. In this invited talk, he will present many innovative paper-based biosensors and paper-based batteries that his research group recently developed especially for flexible and wearable applications. Details of the frontier of research to improve the performance of the devices will be discussed, followed by a critical perspective on strategic future directions.

Colloidal Nanoplates-based Fibers for Wearable Energy and Sensor Applications
Tae Hee Han
Hanyang University, Seoul, South Korea

Large-scale, straightforward wet-spinning of two-dimensional (2D) materials has emerged as a promising direction for processability to develop meter-long dimensional fibers. For example, graphene fibers (GFs) have great potential in future portable wearable electronics, which have gained considerable attention owing to high electrical conductivity, lightweight, tiny volume, outstanding mechanical flexibility, excellent deformability, low cost, and the ability to be woven into smart textile fabrics. Herein this work, I introduce that GFs are derived from wet-spinning of graphene oxide (GO) dispersions which are demonstrated as safe electrodes for wearable energy and sensor applications. GFs can be a potential wearable chemical sensor platform by taking advantage of excellent mechanical flexibility and deformability. Additionally, hybrid metal oxide/GF all-solid-state supercapacitors exhibited an enhanced volumetric capacitance compared to pristine GF electrodes. The excellent performance and simple large-scale wet-spinning process pave the way for portable wearable electronics devices. Finally, I will introduce this wet-spinning strategy can applied to another type of 2D nanosheets, MXene. Because Ti3C2Tx MXene fiber has dense lamella and a highly aligned multiscale structure, MXene fibers exhibit outstanding electrical conductivity and a high mechanical modulus compared with other MXene-based assemblies.

INDUSTRY SPEAKERS

Progress of Organic Semiconductor based NIR- SWIR Image Sensor
Phoebe Tan
Raynergy Tek Incorporation, Taiwan

The interests of using organic semiconductor as the photodetector for image sensor application is on the rise. Raynergy Tek's R&D has demonstrated a bulk-heterojunction (BHJ) organic composite featuring a self-filtering light responsive characteristic at Near Infrared level.Basically, a photodetector is designed to interact with incoming photons that have specific wavelengths and required a color filter to enable the selective spectral response of the photodetector as well as to eliminate the crosstalk interference resulting from ambient lights. However, a reduced detection sensitivity of the photodetector is inevitable due to an imperfect light filtering, which greatly limits the practical applications of selective-response photodetectors. By carefully tuning of the thickness and formulation of BHJ film, the organic photodetector (OPD) demonstrates a high-selective spectral response to the infrared (IR) radiation without the need of applying a color filter. As a result, the self-filtering top-illuminated OPD exhibits a narrowband external quantum efficiency (EQE) of 53% with a narrow full width at half-maximum (fwhm) of 56 nm centering at 1080 nm. A high responsivity of 0.46 A W–1 is also achieved at 1080 nm wavelength due to the self-filtering characteristic. The research and development progresses of high-performance Organic semiconductor-based SWIR with detectivity of 10^11 will also be discussed.

Additive Manufacturing of Electronics and Advanced Packaging: A Semiconductor Foundry in a Box
Ahmed Busnaina
NanoOps, Northeastern University, USA

We introduce a scalable and sustainable technology that enables the additive manufacturing of nano and microelectronics, electronic components, and RDL and can reduce the cost by 10-100 times compared to conventional fabrication and be 1000 times faster and 1000 smaller structures than ink-jet-based printing. The nano and microscale printing platform enables the heterogeneous integration of interconnected circuit layers (like CMOS) of printed electronics and sensors at ambient temperature and pressure on rigid or flexible substrates. Printed applications, such as transistors, inverters, diodes, and logic gates, were demonstrated, and displays at the micro and nanoscale using inorganic and organic materials will be presented. The capability of printing RDL, passive and active components monolithically allows the reduction of a board (such as an IOT board) to be within a few mm of the original IC (chip) footprint. Additionally, the number of parts used will be reduced by more than 75% and the footprint by more than 90% to reduce size and weight.

INDUSTRY SPEAKERS

Flexible RF Applications Using AME
Ryan Bahr
Nano Dimension, USA

Industry is showing increased interest and adoption of additive manufactured electronics (AME) for rapid prototyping or innovating novel designs. With a focus on the capabilities of inkjet printing (such as the DragonFly IV), I discuss emerging flexible RF-applications based on academic literature and discussions with industry, as well as highlight future direction of integration of different technologies and novel applications.

Development of an OTFT PDK for Low-Voltage, Flexible Logic Circuits on Plastic Substrates
Alejandro Carreras
Smartkem, United Kingdom

At SmartKem, in our pursuit to develop long-term impact to the field of high quality, high mobility, organic semiconductor materials, we have developed 5V and 3.3V operational logic, with a dual-gate OTFT architecture. Through this, we aim to bring the numerous benefits of OTFT, such as low power consumption - thanks to the power-saving dual gate OTFT compared to PMOS single-gate - and its hybrid integration with CMOS technology, in large area applications, on flexible and printed substrates. For this technology to thrive, of course, there is a strong need for an open-source platform development kit, to enable RTL to GDS synthesis, without the required detailed knowledge of OTFT technology. In this talk, we want to open the floor to questions and reflections, while discussing our current development of an OpenROAD/OpenLane semi-custom PDK.

Flexing the Future: Innovations in Flat Panel Manufacturing for Cutting-Edge Flexible Electronics Applications
Jerome Crocco
InnovaFlex Foundry, USA

InnovaFlex Foundry is a leading force in the evolution of flat panel display technologies within the United States. Our primary focus is on refining and perfecting the fabrication processes for amorphous Silicon (a-Si) as well as IGZO on Gen 4.5 substrates. Our advanced manufacturing processes deliver highly efficient and cost-effective solutions, driving advancements across a broad range of technologies and fulfilling the burgeoning demand within the key markets. Beyond our commitment to a-Si technology, InnovaFlex Foundry is also proactively engaging in research and development activities to develop flexible electronics into existing and future production cycles. With our robust a-Si technology capabilities and forward-looking IGZO integration strategy, InnovaFlex Foundry is firmly positioned at the cutting edge of the flat panel manufacturing industry and serves as a reliable domestic supplier within a complex supply chain. By setting high standards in process efficiency, product quality, and innovative research, we are shaping the future of display technologies and reaffirming our commitment to technological excellence.

INDUSTRY SPEAKERS

Real Printed Electronics Applications: Past, Present, and Future
Khasha Ghaffarzadeh
TechBlick, Germany

Printed electronics is everywhere and yet seems elusive. It is in diverse products ranging from baby diapers to consumer electronics to solar cells to precision missiles, and yet many feel the predicted growth rates have failed to materialize especially as many users still opt for conventional electronics when faced with the complexities of printed electronics. In this talk, we offer an overview of the past, present and future of printed electronic applications. We will showcase and review applications - which are either in the market or are close to commercialization - covering photovoltaics, MLCCs, human-machine-interfaces /HMIs, biosensors, automotive interiors, displays (OLED, QDs and microLEDs), lighting, wearable devices, medical sensors, and many more. In doing so we will demonstrate the depth and breadth of the industry and offer perspective on the future direction of development

TUTORIAL SPEAKERS

Approaches for Scalable and Self-healing Hybrid Electronic Materials
Benjamin Tee
National University of Singapore, Singapore

The growth of flexible and wearable electronics commensurate with the proliferation of microelectronic devices is enabling high impact applications in healthcare and robotics. However, as such electronic devices increase in number, an increasingly urgent need to create materials and devices that can be part of a circular or self-repairable economy becomes critical. In this talk, I will discuss using organic hybrid materials science and engineering approaches as a way to scale skin-like electronic devices for more sustainable technological and societal impact through self-healing or degradability. For example, to scale to human-like performance, neuromorphic engineering provides an exciting avenue to mimic the high performance of the human nervous systems and sensors Critically, the energy efficiency of the human neural networks for learning relies on event-driven, temporally encoded action potential streams. In this talk, I will discuss how we can digitize tactile information through inspiration from somatosensory neural science. We have developed an asynchronous protocol for parallel transmission of tactile information in an artificial peripheral nervous system we call ACES: Asynchronously Coded Electronic Skins The parallel transmission encodes spatial temporal information with very high temporal precision (sub-100ns) even when large numbers > 10,000 sensor nodes are transmitting simultaneously. Such systems can be interfaced with soft sensors or flexible/stretchable electronics to enable more intuitive robotics and healthcare applications.

Bioinspired In-Sensor Computing
Yang Chai
Department of Applied Physics, The Hong Kong Polytechnic University

According to the projection by Semiconductor Research Corporation and Semiconductor Industry Association, the number of sensor nodes exponentially increases with the development of the Internet of Things. By 2032, the number of sensors is expected to be ~45 trillion, which will generate >1 million zettabytes (1027 bytes) of data per year. The massive data from sensor nodes obscure valuable information that we need it most. Abundant data movement between sensor and processing unit greatly increases power consumption and time latency, which poses grand challenges for the power-constraint and widely distributed sensor nodes in the Internet of Things. Therefore, it urgently requires a computation paradigm that can efficiently process information near or inside sensors, eliminate redundant data, reduce frequent data transfer, and enhance data security and privacy. We propose bioinspired in-sensor computing paradigm to reduce data transfer and decrease the high computing complexity by processing data locally. In this tutorial, we will discuss the hardware implementation of the in-sensor computing paradigms at the device and array levels. We will illustrate the physical mechanisms that lead to unique sensory response characteristics and their corresponding computing functions. In particular, bioinspired device characteristics enable the fusion of the sensor and computation functionalities, providing a way for intelligent information processing with low power consumption.

TUTORIAL SPEAKERS

Flexible and Stretchable Inorganic Solar Cells for Wide Ranging Deployment

Nazek El-Atab
King Abdullah University of Science and Technology, Thuwal, Kingdom of Saudi Arabia

Flexible and stretchable solar cells have attracted an increasing amount of interest in the past decade due to their ever-expanding range of applications from wearables and foldable electronics, to buildings and vehicles, among others. In this tutorial, we will discuss the different inorganic active materials that are used in the development of flexible and stretchable photovoltaic devices. In addition, the techniques that have been developed towards the realization of conformal and elastic inorganic solar cells will be reviewed including transfer-printing, the direct deposition on conformal substrates, and the etch-based corrugation technique. The pros and cons of each of these approaches will be evaluated in terms of realized efficiency, resilience, bendiness, as well as economical sustainability.

E-Tattoos – Materials, Design, Manufacturing, Functionalities, and Applications

Nanshu Lu
University of Texas, Austin, USA

E-tattoos are a type of wearable technology that use flexible and stretchable electronics to conform to the soft, deformable and curvilinear surface of human skin. They can be hair-thin, skin-soft, and noninvasive, making them a promising alternative to traditional wearables like smart watches and rings. This tutorial will cover the materials, design, manufacturing, and functionalities of emerging e-tattoos. It will also introduce their potential applications in telemedicine, mobile health, human-robot interactions and fashion. Existing challenges and future directions will be discussed at the end. Attendees are encouraged to ask questions and share their own ideas during the presentation.

Hybrid Printing and Laser Patterning Strategies for Wearable and Implantable Biochemical Sensors

Amay J. Bandodkar
North Carolina State University, USA

In this tutorial, I will discuss how attributes of screen printing and laser patterning techniques can be leveraged for developing new classes of flexible, stretchable, and selfhealing devices with applications in electrochemical sensing. I will discuss key advances in this field with specific examples of wearable and implantable sensors. The tutorial will begin with the need for such devices followed by the key challenges in realizing them using conventional methods. A brief discussion of the fundamentals of printing and laser patterning methodologies will be covered. Strategies to develop customizable, smart inks and unconventional materials processing capabilities of lasers will be a part of the discussion. Finally, demonstrations of tissue-like sensors that are soft, stretchable, and self-healing will be provided. Examples will also include embodiments that combine these fabrication techniques with microfluidics, wireless electronics, and materials engineering to develop advanced biosensing devices for emerging applications.

IEEE SENSORS COUNCIL 25TH ANNIVERSARY ELECTRONICS FOR A SUSTAINABLE FUTURE PANELISTS

John A. Rogers
Northwestern University, USA

Takao Someya
University of Tokyo, Japan

Edzer Huitema
E Ink Corporation, USA

Gregory D. Abowd
Northeastern University, USA

Ashiq Ahamed
Pragmatic Semiconductors, UK

DIVERSITY PANELISTS

Anna-Maria Pappa
Department of Biomedical Engineering, Khalifa University, United Arab Emirates

Natalie Stingelin
Georgia Institute of Technology and School of School of Materials Science & Engineering, USA

Richard Harris
Northeastern University, USA

TUTORIAL SCHEDULE

Sunday, July 9, 2023 ***Room 140***	
8:00-18:00	Registration
8:30-10:00	Nanshu Lu
10:00-10:15	Coffee Break
10:15-11:45	Amay Bandodkar
11:45-13:00	Lunch Break
13:00-14:30	Benjamin Tee
14:30-14:45	Coffee Break
14:45-16:15	Yang Chai
16:15-16:30	Coffee Break
16:30-18:00	Nazek El-Atab
19:00-21:30	Young Professionals/ Welcome Reception *East Village 17th Floor Terrace*

INDUSTRY SPEAKER SCHEDULE

Tuesday, July 11, 2023 ***Auditorium***	
9:30-10:00	Khasha Ghaffarzadeh
10:00-10:30	Phoebe Tan
10:30-11:00	Jerome Crocco
11:00-11:15	Coffee Break
11:15-11:45	Ahmed Busnaina
11:45-12:15	Alejandro Carreras
12:15-12:45	Ryan Bahr

PROGRAM AT-A-GLANCE

Monday July 10, 2023			Tuesday July 11, 2023			Wednesday July 12, 2023		
7:45-17:00	Registration *Atrium*		**7:45-17:30**	Registration *Atrium*		**7:45-17:30**	Registration *Atrium*	
8:30-8:45	Welcome and Introduction *Auditorium*		**8:30-9:30**	Plenary Lecture Edzer Huitema *Auditorium*		**8:45-9:45**	Plenary Lecture Stephanie Lacour *Auditorium*	
8:45-9:45	Plenary Lecture Natalie Stingelin *Auditorium*		**9:30 - 11:00**	Industry Session Part 1 *Auditorium*		**9:45-10:00**	Coffee Break *Atrium*	
9:45-10:00	Coffee Break *Atrium*		**11:00-11:15**	Coffee Break *Atrium*		**10:00-11:30**	Track 1 *Room 140*	Track 10 *Room 142*
10:00-11:30	Track 2 *Room 140*	Track 3 *Room 142*	**11:15-12:45**	Industry Session Part 2 *Auditorium*		**11:30-13:00**	Track 4 *Room 140*	Track 5 *Room 142*
11:30-13:00	Track 6 *Room 140*	Track 7 *Room 142*	**12:45-13:45**	Lunch *Atrium*		**13:00-14:00**	Lunch *Atrium*	
13:00-14:00	Lunch *Atrium*	YP Mentoring Lunch *Atrium*	**13:45-15:15**	Track 8 *Room 140*	Track 9 *Room 142*	**14:00-15:30**	Track 11.7 *Room 140*	Track 13.1 *Room 142*
14:00-15:30	Track 11.1 *Room 140*	Track 11.4 *Room 142*	**15:15-15:30**	Coffee Break *Atrium*		**15:30-16:00**	Coffee Break *Atrium*	
15:30-17:00	Coffee Break *Atrium*	Poster Session *Atrium*	**15:30-17:00**	Track 11.5 *Room 140*	Track 11.6 *Room 142*	**16:00-17:00**	Track 13.2 *Room 140*	Track 13.3 *Room 142*
			17:00-18:00		Track 11.3 *Room 142*	**17:00-17:30**	Concluding Remarks *Auditorium*	
17:15-18:15	Diversity Panel *Auditorium*		**18:00-19:00**	Sustainability Panel *Auditorium*				
18:15 -19:15	WiSe/YP Big Ideas Pitch *Room 140*		**19:30-22:00**	Gala Dinner *MFA*				

10:00 - 11:30
Advanced Fabrication Methods for Flexible Systems Session
Session Chairs: Woo Soo Kim, *Simon Fraser University* & Wei Gao, *Caltech*
Room 140

10:00
INVITED: Soft Electronics with a Noise-Free Hydrogel Damper
Tae-Il Kim
Sungkyunkwan University, Korea

10:30
Advanced Manufacturing of Flexible Electronic Circuits by Transfer Foil Method
Tuomas Happonen{1}, Mikko Hietala{1}, Arttu Huttunen{1}, Terho Kololuoma{2}, Markus Tuomikoski{1}
{1}VTT Technical Research Centre of Finland, Finland; {2}Warming Surfaces Company, Finland

10:45
Strain Isolation for Flexible-to-Stretchable Electrical Interconnects
Zachary Kranz, Elizabeth Shafer, Alexander Watson
University of Dayton, United States

11:00
Massive Fabrication of Carbon Nanotube Transistors by Surface Tension-Driven Inkjet-Printing Method
Soohyun Park, Min Hye Shin, Hongki Kang, Yoonhee Lee
Daegu Gyeongbuk Institute of Science and Technology, Korea

10:00 - 11:30
Physical Sensors & Smart Systems Session
Session Chairs: Dinesh Maddipatla, *Western Michigan University* & Jürgen Kosel, *Silicon Austria Labs*
Room 142

10:00
INVITED: OLED-Based Infrared-to-Visible Up-Conversion Devices
Do Young Kim
Oklahoma State University, United States

10:30
User-Centric Design: Flexible Strain Sensor Adhesive Tape
Vetrivel Sankar, Krishnan Balasubramaniam, Sundara Ramaprabhu
Indian Institute of Technology Madras, India

10:45
A Textile Based Capacitive Pressure and Shear Force Sensor
Stephan Schuler, Phillip Petz, Florian Eibensteiner, Josef Langer
University of Applied Sciences Upper Austria, Austria

11:00
Flexible Hybrid Electronics Based Condition Monitoring System for Sealed Containers
Masoud Panahi, Anthony Hanson, Dinesh Maddipatla, Simin Masihi, Binu Baby Narakathu, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States

11:15
Development of Graphene-Based Flexible Thermocouples for Wearable Applications
Umar Farooq, Babar Ali, Hossein C. Bidsorkhi, Alessandro G. D'Aloia, Maria Sabrina Sarto
Sapienza University of Rome, Italy

11:30-13:00
Low-Power & Green Electronics Session
Session Chairs: Hans Kleemann, *TU Dresden* & Niko Münzenrieder, *Free University of Bozen*
Room 140

11:30
INVITED: Material and Device Designs in Biomimetic Polymer Electronics
Sihong Wang
University of Chicago, United States

12:00
Sputtered Zinc Electrodes on Pullulan Substrates for Flexible Biodegradable Transient Electronics
Andrew Cook{1}, Keri Goodwin{1}, Paul Taylor{2}, Ertan Balaban{3}, Maria Alfredsson{2}, Robert Horne{2}, David Bird{1}, John Batchelor{2}, Alexander Casson{3}
{1}Centre for Process Innovation, United Kingdom; {2}University of Kent, United Kingdom; {3}University of Manchester, United Kingdom

12:15
Dual-Gate Transistors Using Contact Printed ZnO Nanowires
João Neto{2}, Abhishek Singh Dahiya{2}, Adamos Christou{2}, Ayoub Zumeit{2}, Luca De Pamphilis{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

12:30
Flexible Thin-Film Temperature Sensors on Gelatin-Based Biodegradable Substrates for the Development of Green Electronics
Alejandro Carrasco-Pena{1}, Federica Catania{1}, Michael Haller{1}, Michael Nippa{1}, Giuseppe Canterella{2}, Niko Münzenrieder{1}
{1}Free University of Bozen-Bolzano, Italy; {2}University of Modena and Reggio Emilia, Italy

12:45
Leaf Electronics: Nature-Based Substrates and Electrodes for Organic Electronic Applications
Rakesh Nair, Laura Teuerle, Jakob Wolansky, Hans Kleemann, Karl Leo
Technische Universität Dresden, Germany

11:30 - 13:00
Hybrid Systems Session
Session Chairs: Jasmin Aghassi, *Karlsruhe Institute of Technology* & Muhammad Hussain, *Purdue University*
Room 142

11:30
INVITED: Novel Metal-Mesh Transparent Conductors for Flexible and Stretchable Electronics Applications
Zheng Cui{1}, Xiaolian Chen{2}, Wenming Su{2}
{1}Jiangsu Industrial Technology Research Institute, China; {2}Suzhou Institute of Nanotech and Nanobionics, China

12:00
Ultra-Thin Chips for High-Performance Semi-Transparent Flexible Electronics
Sihang Ma{2}, Abhishek Singh Dahiya{2}, Xenofon Karagiorgis{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

12:15
Short Wave Infrared Upconversion Imager with Electron Blocking Layer to Screen Electron Injection Into Photo-Sensitive Layer
Chanho Shin, Ning Li, Tse Nga Ng
University of California, San Diego, United States

12:30
Fabrication of Concave-Shaped Ultra-Thinned FDSOI CMOS Circuit for Curved Image Sensor
Shigeyuki Imura, Masahide Goto, Toshikatsu Sakai, Hiroto Sato
Japan Broadcasting Corporation NHK, Japan

12:45
Inkjet-Printed Soft Intelligent Medical Bracelet for Simultaneous Real-Time Sweat Potassium (K+), Sodium (Na+), and Skin Temperature Analysis
Ata Golparvar{1}, Sarah Tonello{2}, Ali Meimandi{1}, Sandro Carrara{1}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}University of Padova, Italy

14:00 - 15:30
Printed Sensors & Devices for Bioelectronics & Digital Health Session
Session Chairs: Hongki Kang, *Daegu Gyeongbuk Institute of Science and Technology* & Gerd Grau, *York University*
Room 140

14:00
INVITED: Direct Writing of Elastic Conductors for three-Dimensional skin-Mountable Electronics
Seungjun Chung
Korea Institute of Science and Technology, Korea

14:30
Optimization of Inkjet-Printed Seed Layer Based Flexible, Transparent Metal Electrode for Bio-Signal Sensing
Duhee Kim, Boil Kim, Nari Hong, Han Kyoung Choe, Hongki Kang
Daegu Gyeongbuk Institute of Science and Technology, Korea

14:45
Full-Lig Wireless Batteryless Sensor for the Detection of Amines
Andrea Salvia, Alessio Mostaccio, Gianni Antonelli, Eugenio Martinelli, Gaetano Marrocco
University of Roma Tor Vergata, Italy

14:00 - 15:30
Sensors for Sustainable Digital Agriculture Session
Session Chair: Tse Nga Ng, *University of California*
Room 142

14:00
INVITED: Sensors for Sustainable Digital Agriculture - an Overview
Shane Ward
University College Dublin, Ireland

14:30
INVITED: All-Carbon Nanomaterial Inks for Print-in-Place, Recyclable, and Water-Based Electronics
Aaron Franklin
Duke University, United States

15:00
A Low-Cost, Flexible Electrochemical Sensor for Nitrate Detection in Water
Shah Zayed Riam, Md. Najmul Islam, Akm Sarwar Inam, Shawana Tabassum
University of Texas at Tyler, United States

15:15
Manufacturing of Flexible, Impedimetric Potassium Sensors
Eva-Maria Korek, Evanthia Kounoupioti, Ralf Brederlow
Technical University of Munich, Germany

15:30 - 17:00
Focus Session Posters Session
Session Chair: Ben Davaji, *Northeastern University*
Room: Atrium

Laser-Printed Highly Sensitive Flexible Urea Sensors
Yangyi Huang{1}, Connie Kong Wai Lee{1}, Na Jiang{2}, Mitch Guijun Li{1}
{1}Hong Kong University of Science and Technology, Hong Kong; {2}Renji Hospital, Shanghai Jiaotong University School of Medicine, China

Impact of 3D Printed Infill Patterns on Flexible Non-Invasive Serum Glucose Sensor
Jeevan Persad, Megan Mahadeo, Sean Rocke
University of The West Indies, Trinidad and Tobago

Using a Paper Carrier to Screen Print on Polyurethane Film and Fabricate ECG Probes
Liam Johnson, Alexander Casson
University of Manchester, United Kingdom

Soft Normal and Shear Force Sensor for Underwater Robotic Applications
David Kamp, Rafsan Subad, Kihan Park
University of Massachusetts Dartmouth, United States

Fabrication and Testing of a PneuNet Actuator-Based Caterpillar Like Amphibian Soft Robot for Multi-Terrain Applications
Sourav Karmakar, Astitva Ranjan, Aftab Hussain
International Institute of Information Technology Hyderabad, India

Au-Based Biocompatible Capacitive Strain Sensor
Mugeun Lee, Hwajoong Kim, Jinho Kim, Minji Jeong, Jaehong Lee
Daegu Gyeongbuk Institute of Science and Technology, Korea

Powering Wire-Mesh Circuits Through MEMS Fiber-Grippers
Nathan Song{1}, Danming Wei{2}, Cindy Harnett{2}
{1}University of California, Berkeley, United States; {2}University of Louisville, United States

15:30 - 17:00
Poster 1 Session
Session Chair: Ben Davaji, *Northeastern University*
Room: Atrium

Optimised Inkjet-Printing Parameters and Processing Techniques for an Exemplary Structure of an Oxygen Sensor on a Polyimide Substrate
Lisa Petani, Anja Schweizer, Christian Pylatiuk, Peter Stiller, Klaus-Martin Reichert, Ulrich Gengenbach, Martin Ungerer
Karlsruhe Institute of Technology, Germany

Screen-Printed Liquid-Metal Inks for Multilayer Flexible Electronics
Elizabeth Shafer, Zachary Kranz, Alexander Watson
University of Dayton, United States

Additive Manufactured Compliant Surface Reflectance Sensor
Teemu Salo, Maija Luukko, Aki Halme, Jukka Vanhala
Tampere University, Finland

Electrospun PANi Nanofibers for Biodegradable Sensors
Xenofon Karagiorgis{2}, Fengyuan Liu{2}, Sofia Sandhu{2}, Peter Skabara{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

A 3D Printed Architecture Sensor for Structural Health Monitoring
Tae Ho Kim, Hadi Moeinnia, Woo Soo Kim
Simon Fraser University, Canada

A 3D Printed Wearable Electromyography Wristband
Haotian Su, Tae Ho Kim, Hadi Moeinnia, Woo Soo Kim
Simon Fraser University, Canada

Machine Learning Based Characterization of a Waterproofed Soft Multi-Directional Force Sensor
Md Mahmud Hasan Saikot{1}, Rafsan Subad{2}, Kihan Park{2}
{1}Bangladesh University of Engineering and Technology, Bangladesh; {2}University of Massachusetts Dartmouth, United States

A Comparison of Relative Seebeck Coefficients for Screen Printed Flexible Thermocouples Using Commercially Available Conductive Inks
Cameron Anderson{2}, Z. Hugh Fan{2}, Jorg Richstein{1}, Mark Sussman{1}, Toshikazu Nishida{2}
{1}Jabil Inc., United States; {2}University of Florida, United States

Capacitive Pressure Sensors Utilizing a Conductive Human Fingerprint Microstructure
Alexander Johnson{2}, Nimal Jagadeesh Kumar{2}, Arash Pouryazdan{2}, Niko Münzenrieder{1}
{1}Free University of Bozen-Bolzano, Italy; {2}University of Sussex, United Kingdom

Compact Passive RFID Memory Sensor for Temperature Threshold Detection
Sheikh Dobir Hossain, Bhushan Lohani, Ryan M. Price, Jorge A. Ochoa, Robert C. Roberts
University of Texas at El Paso, United States

OPTL: Robust and Area-Efficient Pass Gate Logic for Organic Transistors
Zhaoxing Qin{1}, Kunihiro Oshima{1}, Kazunori Kuribara{2}, Takashi Sato{1}
{1}Kyoto University, Japan; {2}National Institute of Advanced Industrial Science and Technology, Japan

Printed Memristors Using Hydrothermally Grown Zinc Oxide Nanowires
Luca De Pamphilis{2}, Abhishek Singh Dahiya{2}, Sihang Ma{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

Fabrication Techniques for Multi-Layer Printed Flexible Hybrid Sensor Systems
Jeneel Pravin Kachhadiya, Joseph Andrews
University of Wisconsin-Madison, United States

Flexible Stencil-Printed Piezoelectric Transducer Arrays for Catheter Based Ultrasound Applications
Batin Karahasanoglu, Lee W Bradley, Helen H Snyder, Begum Atasoy, Yusuf Samet Yaras, Fahrettin Levent Degertekin
Georgia Institute of Technology, United States

15:30 - 17:00
Poster 2 Session
Session Chair: Ben Davaji, *Northeastern University*
Room: Atrium

Development of a Printed Impedance Based Electrochemical Sensor for E. coli Detection
Parinaz Eskandari, Alimohammad Haji Adineh, Dinesh Maddipatla, Massood Atashbar
Western Michigan University, United States

Development of a Fully-Printed Flexible Polystyrene-Based Temperature Sensor with Anti-Humid Property
Ahmad Al Shboul, Ankur Gohel, Mohsen Ketabi, Ricardo Izquierdo
École de Technologie Supérieure ÉTS, Canada

Characterisation and Quantification of Crosstalk on a Velostat-Based Flexible Pressure Sensing Matrix
L Lakshmanan, Mohee Datta Gupta, Anis Fatema, Aftab Hussain
International Institute of Information Technology Hyderabad, India

Fabrication and Statistical Analysis of Large-Scale ZnO NW Based Synaptic Transistors
Fengyuan Liu{2}, Radu Chirila{2}, Adamos Christou{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

Smart Diaper Embedded with Fully Printed Sensors for Wireless Healthcare and Monitoring
Shawkat Ali{2}, Arshad Khan{1}, Amine Bermak{1}
{1}Hamad Bin Khalifa University, Qatar; {2}King Abdullah University of Science and Technology, Saudi Arabia

Inkjet Printed Inverter Showing Binary/Ternary Logic Operation Depending on its Previous Logic State
Seoyeon Jung{2}, Somi Kim{1}, Hocheon Yoo{1}, Bongjun Kim{2}
{1}Gachon University, Korea; {2}Sookmyung Women's University, Korea

Direct Recording of Intracellular Potentials of Cardiomyocytes Through Solution Processed Planar Electrolyte-Gated Field-Effect Transistors
Adrica Kyndiah{2}, Michele Dipalo{1}, Alireza Molazemhosseini{1}, Fabrizio Viola{1}, Francesco Modena{1}, Giuseppina Iachetta{1}, Nicolas F. Zorn{3}, Željko Popović{4}, Goran Stojanović{4}, Jana Zaumseil{3}, Francesco De Angelis{1}, Mario Caironi{2}
{1}Istituto Italiano di Tecnologia, Italy; {2}Italian Institute of Technology, Italy; {3}Ruprecht-Karls Universität Heidelberg, Germany; {4}University of Novi Sad, Serbia

Flexible Wearable Nanomaterial-Based Sensing Device for Back Pain and Injury Prevention
Emma Jacobs, Aaron Rosen, Britta Berg-Johansen, Long Wang
California Polytechnic State University, United States

15:30 - 17:00
Supercapacitors & Triboelectric Nanogenerators Poster Session
Session Chair: Ben Davaji, *Northeastern University*
Room: Atrium

Flexible Textile Zinc Ion Supercapacitor
Sheng Yong, Yi Li, Stephen Beeby
University of Southampton, United Kingdom

High Voltage Cellulose Based Flexible Triboelectric Nanogenerator
Xingzhe Zhang{2}, Duo He{2}, Qiang Yang{1}, Dinesh Maddipatla{2}, Massood Atashbar{2}
{1}Michigan State University, United States; {2}Western Michigan University, United States

MXene Based Triboelectric Nanogenerator on Fabric Platform for Wearable Energy Harvesting Applications
Valliammai Palaniappan, Himanaga Rama K.M. Emani, Alimohammad Haji Adineh, Masoud Panahi, Gazelle Hajimazdarani, Dinesh Maddipatla, Binu Baby Narakathu, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States

15:30 - 17:00
Emerging Applications 2 Poster Session
Session Chairs: Ben Davaji, *Northeastern University* & Nanshu Lu, *UT Austin*
Room: Atrium

A Flexible PCB Based Out of Plane Bimorph MEMS Thermal Actuator
Tao Chen, Cyrus Shafai
University of Manitoba, Canada

Flexible Fabric Electrodes Integrated with Mouthguard for Electroocoulogram Measurement
Han Nguyen, Shibam Debbarma, Sharmistha Bhadra
McGill University, Canada

Broadband Sensing with High-Performance Non-Fullerene Acceptor-Based Organic Photodetectors
Hossein Anabestani, Sharmistha Bhadra
McGill University, Canada

A Comparison of High Dielectric Fillers for a Stitchable Flexible Capacitive Sensor
Nimal Jagadeesh Kumar{2}, Alexander Johnson{2}, George Valsamaki{2}, Gene Gristock{2}, Daniel Roggen{2}, Niko Münzenrieder{1}
{1}Free University of Bozen-Bolzano, Italy; {2}University of Sussex, United Kingdom

13:45 - 15:15
Reliability, Simulation & Modelling Session
Session Chairs: Massood Atashbar, *Western Michigan University* & Jasmin Aghassi, *Karlsruhe Institute of Technology*
Room 140

13:45
INVITED: Finding an Experimentally Validated 2D Model of Organic Electrochemical Transistors
Michael Skowrons, Pushpa Paudel, Björn Lüssem
Universität Bremen, Germany

14:15
Feature-Based Machine Learning for Predicting Resistances in Printed Electronics
Landon Ivy{1}, Yutong Xie{1}, Theo Lobo{1}, Ved Gund{1}, Benyamin Davaji{2}, Meera Garud{1}, Peter Doerschuk{1}, Amit Lal{1}
{1}Cornell University, United States; {2}Northeastern University, United States

14:30
Efficient Calibration of Velostat-Based Flexible Pressure Sensor Matrix
Shirley Chauhan, Anis Fatema, Ivin Kuriakose, Aftab Hussain
International Institute of Information Technology Hyderabad, India

14:45
Single-Molecule Bioelectronic Sensor: Improving Reliability with Machine Learning Approaches
L. Sarcina{2}, C. Scandurra{2}, M. Caputo{2}, M. Catacchio{2}, C. Di Franco{2}, P. Bollella{2}, M. Chironna{2}, F. Torricelli{3}, I. Esposito{4}, R. Österbacka{1}, G. Scamarcio{2}, Eleonora Macchia{2}, Luisa Torsi{2}
{1}Abo Akademi, Finland; {2}University of Bari, Italy; {3}University of Brescia, Italy; {4}University of Dusseldorf, Germany

15:00
Design of a Flexible Ammonia Gas Sensor with Interdigitated Electrodes for Food Packaging Applications
Ali Yadollahi, Dinesh Maddipatla, Simin Masihi, Bradley Bazuin, Paul Fleming, Massood Atashbar
Western Michigan University, United States

13:45 - 15:15
Printed Smart Tags & Communication Devices Session
Session Chairs: Shweta Agarwala, *Aarhus University* & Gaetamo Marrocco*, University of Roma Tor Vergata*
Room 142

13:45
INVITED: Flexible Wireless Systems for E-Textiles
Stephen Beeby
University of Southampton, United Kingdom

14:15
Integration of Supercapacitors to Trigger In-Situ Electropolymerization for Irreversible Visual Indicators
Elin Howard{3}, Hamed Pourkheirollah{1}, Carlos Pinheiro{3}, Cesar Laia{2}, Jorge Parola{2}, Matti Mäntysalo{1}, Donald Lupo{1}
{1}Tampere University, Finland; {2}Universidade NOVA de Lisboa, Portugal; {3}Ynvisible Interactive Inc, Germany

14:30
Multi-Process Additive Manufacturing of Flexible Patch Antennas
Andrew Faber, Nathan Schatz, Connor Smith, Hatem ElBidweihy
United States Naval Academy, United States

14:45
Towards Printed Conductive-Bridge Memory Devices Based on Mesoporous SiO2 Film
Roxane Mamberti, Evangéline Bènevent, Marc Bocquet, David Grosso, Tomas Fiorido, Magali Putero
Aix-Marseille Université, France

15:00
3D Printed Liquid Metal Litz Wire for Efficient Wireless Power Transmission
Md Saifur Rahman, Seth Mellinger, Julia Huddy, William Scheideler
Dartmouth College, United States

15:30 - 17:00
Flexible Sensory Systems & Human-Machine Interfaces for Robotic Application Session
Session Chairs: Gerd Grau, *York University* & Woo Soo Kim, *Simon Fraser University*
Room 140

15:30
INVITED: A Tomographic Tactile Sensing Approach for Soft Robot Skins
Hyosang Lee
University of Stuttgart, Germany

16:00
Thermal Stability of a Fully Printed Ultra-Thin Organic Pre-Amplifier Circuit Meant for On-Skin Applications
Aregaw Kujansuu{1}, Rei Shiwaku{2}, Tomohito Sekine{2}, Hiroyuki Matsui{2}, Shizuo Tokito{2}, Matti Mäntysalo{1}, Mika-Matti Laurila{1}
{1}Tampere University, Finland; {2}Yamagata University, Japan

16:15
Fully Inkjet-Printed Soft Wearable Strain Sensors Based on Metal/Polymer Composite Sensing Films
Arshad Khan{1}, Shawkat Ali{2}, Aditya Shekhar Nittala{3}, Kashif Riaz{1}, Amine Bermak{1}
{1}Hamad Bin Khalifa University, Qatar; {2}King Abdullah University of Science and Technology, Saudi Arabia; {3}University of Calgary, Canada

16:30
A Novel Haptic System with Advanced Force Sensing Capabilities for Soft-Robotic Applications
Sergei Akhmatdinov, Hakan Dogdu, Matthew Haley, Masoud Panahi, Anthony Hanson, Simin Masihi, Alimohammad Haji Adineh, Valliammai Palaniappan, Dinesh Maddipatla, Massood Atashbar
Western Michigan University, United States

16:45
Transparent Piezoelectric Nanogenerator for Self-Powered Force Sensing Applications
Nitheesh M. Nair{2}, Swati Deswal{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

15:30 - 17:00
Intelligent Soft Machines Merging Flexible Sensors & Soft Actuators Session
Session Chair: Xiaoguang Dong, *Vanderbilt*
Room 142

15:30
Electronically Integrated Microscopic Robots
Itai Cohen
Cornell University, United States

16:00
Addressing Challenges in Minimally Invasive Surgery Through Soft Robotics
Sheila Russo
Boston University, United States

16:30
Fabrication and Characterization of a Dielectric Elastomer Actuator Based Flapping Wing
D Niteesh, Shreya Malkurthi, Chetanya Goyal, Aftab Hussain
International Institute of Information Technology Hyderabad, India

16:45
Flexible Mechanical Sensors with Time-Dependent, Viscoelastic Responses
Katherine Riley, Andres Arrieta
Purdue University, United States

17:00 - 18:00
Wearable Theranostic Devices Session
Session Chairs: Yangzhi Zhu, *Terasaki* & Wujin Sun, *Virginia Tech*
Room 142

17:00
INVITED: Wireless Smart Bandage with Integrated Sensors and Stimulators for Advanced Wound Care and Accelerated Healing
Yuanwen Jiang
University of Pennsylvania, United States

17:30
INVITED: Fabrication and Use of Microneedle Equipped Devices for Wound Healing Applications
Ali Tamayol
University of Connecticut Health Center, United States

10:00 - 11:30
Emerging Organic Materials Session
Session Chairs: Canek Fuentes, *Northeastern University* & Niko Münzenrieder, *Free University of Bozen*
Room 140

10:00
INVITED: Graphene-Based Rapid, Multiplexed, Easy, and Cheap Sensing for Personalized Medicine and Epidemiology
Kenneth Burch
Laboratory for Assembly and Spectroscopy of Emergence, Boston College, United States

10:30
A Multi-Functional Organic Electronic Smart Material
Amos Bardea{1}, Alexander Axelevitch{1}, Fernando Patolsky{2}
{1}Holon Institute of Technology, Israel; {2}Tel Aviv University, Israel

10:45
Thermal Resistivity of FFF Printed Carbon Black Doped Polymers
Heime Jonkers, Dimitrios Kosmas, Jurriaan Schmitz, Gijs Krijnen
University of Twente, Netherlands

11:00
Spray-Coated Thin-Film Organic Memristor for Neuromorphic Applications
Bajramshahe Shkodra{2}, Mattia Petrelli{2}, Ali Douaki{2}, Mukhtar Ahmad{2}, Antonio Altana{2}, Luisa Petti{2}, Sandro Carrara{1}, Paolo Lugli{2}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Free University of Bozen-Bolzano, Italy

11:15
Flexible Organic Phototransistors with Limit of Detection Down to 28 pW/cm2
Mattia Scagliotti{1}, Antonio Valletta{1}, Sabrina Calvi{2}, Luigi Mariucci{1}, Matteo Rapisarda{1}
{1}CNR-IMM, Italy; {2}Università di Roma Tor Vergata, Italy

10:00 - 11:30
Emerging Applications 1 Session
Session Chairs: Jia Liu, *Harvard University* & Nanshu Lu, *UT Austin*
Room 142

10:00
INVITED: Biphasic Conductive Inks & Organogels for Soft Machines and Bioelectronics
Carmel Majidi
Carnegie Mellon University, United States

10:30
An Inkjet-Printed Inverter Array Realizing a Physically Unclonable Function
Alexander Scholz, Sophie Sauva, Jasmin Aghassi-Hagmann
Karlsruhe Institute of Technology, Germany

10:45
Direct Writing of Liquid Metal Microheaters for Microvalve Applications
Navid Hussain{2}, Alexander Scholz{2}, Tobias Spratte{1}, Christine Selhuber-Unkel{1}, Michael Hirtz{2}, Jasmin Aghassi-Hagmann{2}
{1}Heidelberg University, Germany; {2}Karlsruhe Institute of Technology, Germany

11:00
Edible Electronics and Robofood: A Move Towards Sensors for Edible Robots and Robotic Food
Valerio Francesco Annese, Giulia Coco, Valerio Galli, Pietro Cataldi, Mario Caironi
Italian Institute of Technology, Italy

11:15
Exploration of Lossy Posture Classification Model Using In-Bed Flexible Pressure Sensors
Aekyeung Moon{1}, Seung Woo Son{3}, Minjun Kim{1}, Seyun Chang{2}, Haeji Park{2}
{1}Electronics and Telecommunications Research Institute, Korea; {2}Midas H&T, Inc, Korea; {3}University of Massachusetts Lowell, United States

11:30 - 13:00
Recent Advances in Organic Bioelectronics for Sensing Applications Session
Session Chairs: Eleonora Macchia, *University of Bari* & DongHee Son, *Sungkyunkwan University*
Room 140

11:30
INVITED: The Future of Cardiac Biomarker Sensing Using gFET Technology
Sabine Szunerits
University of Lille, France

12:00
Printed Flexible Carbon Black-Based Sensor for Nitrite Detection in Medical Applications
Ahmad Al Shboul, Dianne Pacheco, Ricardo Izquierdo
École de Technologie Supérieure ÉTS, Canada

12:15
Selective Detection of H2S Gas Using a Tin (II) Sulfide Based Chemiresistive Sensor with Schottky Contact
Venkata Ramesh Naganaboina, Satish Bonam, Shiv Govind Singh
Indian Institute of Technology Hyderabad, India

12:30
Flexible Sensor and Readout Circuitry for Continuous Ion Sensing in Sweat
Mattia Petrelli{2}, Ata Golparvar{1}, Ali Meimandi{1}, Bajramshahe Shkodra{2}, Martina Aurora Costa Angeli{2}, Aniello Falco{2}, Paolo Lugli{2}, Luisa Petti{2}, Sandro Carrara{1}
{1}École Polytechnique Fédérale de Lausanne, Switzerland; {2}Free University of Bozen-Bolzano, Italy

11:30 - 13:00
Energy Harvesting & Storage Applications Session
Session Chair: Matti Mäntysalo, *Tampere University*
Room 142

11:30
INVITED: Photodetectors and solar cells for robotics and wearable electronics
Jean-Michel Nunzi
Queens University, Canada

12:00
Plasma Printed Antenna for Flexible Battery-Less Smart Mask for Lung Health Monitoring
Harikrishnan Muraleedharan Jalajamony{1}, Midhun Nair{1}, Pranay Doshi{2}, Ram Prasad Gandhiraman{2}, Renny Fernandez{1}
{1}Norfolk State University, United States; {2}Space Foundry Inc, United States

12:15
Self-Powered Flexible Triboelectric Nanogenerators (TENGs) Based on Lateral Sliding Mode
Sam Ali, Dinesh Maddipatla, Simin Masihi, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States

12:30
Laser Patterned Flexible Cathode with Low Tortuosity for Fast Charging Lithium-Ion Battery Applications
Himanaga Rama K.M. Emani, Valliammai Palaniappan, Dinesh Maddipatla, Gazelle Hajimazdarani, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States

12:45
A Low Cost Triboelectric Nanogenerator Utilizing Recycled Household Materials for Mitigating Municipal Solid Waste
Muhammad Umaid Bukhari{3}, Kashif Riaz{3}, Arshad Khan{2}, Khawaja Qasim Maqbool{1}, Bo Wang{2}, Amine Bermak{2}
{1}Bahria University, Pakistan; {2}Hamad Bin Khalifa University, Qatar; {3}Information Technology University of the Punjab, Pakistan

14:00 - 15:30
Fiber-Based Soft Sensors & Devices for Wearable & Bioelectronics Session
Session Chairs: Jaehong Lee, *DGIST* & Chanho Shin, *University of California, San Diego*
Room 140

14:00
INVITED: Paper-Based Wearable Biosensors and Biobatteries
Seokheun Choi
State University of New York at Binghamton, United States

14:30
Construction and Performance of a Flexible and Eco-Friendly Nanocellulose–Graphite-Based Pressure Sensor for Wearable Applications
Xingru Chen, Shuo Mao, Yixin Wang, Hongyu Yu
Hong Kong University of Science and Technology, Hong Kong

14:45
Polypyrrole-Based Cotton Flexible Pressure Sensor Using In-Situ Chemical Oxidative Polymerization
Anis Fatema, Saurabh Mishra, Mohee Datta Gupta, Aftab Hussain
International Institute of Information Technology Hyderabad, India

15:00
INVITED: Colloidal Nanoplates-Based Fibers for Wearable Energy and Sensor Applications
Tae Hee Han
Hanyang University, Korea

14:00 - 15:30
Sensors Letters 1 Session
Session Chair: Matti Mäntysalo, *Tampere University*
Room 142

14:00
Effect of Voltage Boundary Conditions on the Sensitivity and Design of Coplanar Capacitive Sensors
Neda KaramiMohammadi, Joseph Andrews
University of Wisconsin-Madison, United States

14:15
Flex-SNN: Spiking Nerural Network on Flexible Substrate
Kunihiro Oshima{1}, Kazunori Kuribara{2}, Takashi Sato{1}
{1}Kyoto University, Japan; {2}National Institute of Advanced Industrial Science and Technology, Japan

14:30
Exploring Force Sensing with 3-D Printing: A Study on Constriction Resistance and Contact Phenomena
Anders Frem Wolstrup, Anders Eiersted Molzen, Jon Spangenberg, Tiberiu Gabriel Zsurzsan
Danmarks Tekniske Universitet, Denmark

14:45
Graphene-Based Smart Insole Sensor for Pedobarometry and Gait Analysis
Babar Ali, Negin Faramarzi, Umar Farooq, Hossein Cheraghi Bidsorkhi, Alessandro Giuseppe D'Aloia, Alessio Tamburrano, Maria Sabrina Sarto
Sapienza University of Rome, Italy

15:00
Molecular Ferroelectric Based Biocompatile Flexible Piezoelectric Pressure Sensor
Swati Deswal{2}, Gaurav Khandelwal{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

16:00 - 17:00
Sensors Letters 2 Session
Session Chair: Ravinder Dahiya, *Northeastern University*
Room 140

16:00
Silk Nanofibers Based Soft and Degradable Capacitive Pressure Sensor Arrays
Dina Anna John{3}, Chithra Parameswaran{1}, Sofia Sandhu{3}, Ravinder Dahiya{2}
{1}Indian Institute of Science, India; {2}Northeastern University, United States; {3}University of Glasgow, United Kingdom

16:15
Silicone / Carbon Black-Filled Elastomer Based Self-Healing Strain Sensor
Niloofar Saeedzadeh Khaanghah{1}, Hugo de Souza Oliveira{1}, Raheel Riaz{1}, Federica Catania{1}, Martina Aurora Costa Angeli{1}, Luisa Petti{1}, Giuseppe Cantarella{2}, Niko Münzenrieder{1}
{1}Free University of Bozen-Bolzano, Italy; {2}University of Modena and Reggio Emilia, Italy

16:30
Permeable Thermistor Temperature Sensors Based on Porous Melamine Foam
Hugo de Souza Oliveira{2}, Niloofar Saeedzadeh Khaanghah{2}, Violet Yinuo Han{1}, Alejandro Carrasco-Pena{2}, Alexandra Ion{1}, Michael Haller{2}, Giuseppe Cantarella{3}, Niko Münzenrieder{2}
{1}Carnegie Mellon University, United States; {2}Free University of Bozen-Bolzano, Italy; {3}University of Modena and Reggio Emilia, Italy

16:45
3D Printed Microfluidic Coils with Liquid Metal for Wireless Motion Sensing
Radu Chirila{2}, Abhishek Singh Dahiya{2}, Cristian Urlea{2}, Philippe Schyns{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

16:00 - 17:00
Sensors Letters 3 Session
Session Chair: Cheng Yao Lo, *National Tsing Hua University*
Room 142

16:00
Nanowires Based Stretchable Strain Sensor for Wearable Applications
Dhayalan Shakthivel{2}, Nitheesh M. Nair{2}, Ravinder Dahiya{1}
{1}Northeastern University, United States; {2}University of Glasgow, United Kingdom

16:15
Direct Printed Flexible Organic Thin Film Transistors with Cross-Linked PVA-Carrageenan Gate Dielectric
Roslyn Massey, Xiaoyu Song, Ravi Prakash
Carleton University, Canada

16:30
Flexible and Printed Chemiresistive Ammonia Gas Sensors Based on Carbon Nanotube and Conjugated Polymers: A Comparison of Response and Recovery Performance
Annelot Nijkoops, Manuela Ciocca, Soufiane Krik, Ali Douaki, Arvind Gurusekaran, Sahira Vasquez, Mattia Petrelli, Martina Aurora Costa Angeli, Luisa Petti, Paolo Lugli
Free University of Bozen-Bolzano, Italy

16:45
Novel Graphene Transfer Method to Silicone and its Sensing Application on Porous PDMS
Padmanabh Pancham{4}, Anupam Mukherjee{2}, Boong Yuan{5}, Peichen Yu{5}, Wen-Hsin Chiu{4}, Gufran Ahmad{1}, Sandipan Mallik{3}, Cheng-Yao Lo{4}
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