

Welcome Message

Dear Colleagues/Friends,

We warmly welcome you to Glasgow, UK, to present, exhibit, and participate in the 1st IEEE International Conference on Flexible and Printable Sensors and Systems (FLEPS 2019).

This year event will establish a series of international conferences and exhibitions aiming at the latest developments in the area of flexible, printable, large-area sensors and systems enabling emerging applications in modern electronics.

The IEEE FLEPS 2019 is sponsored by the IEEE Sensors Council and is the only IEEE event exclusively dedicated to Flexible, printable and large-area sensor systems and applications.

In recent years, we have seen a trend to repurpose smart sensor systems and electronics to meet the demands in the emerging field of flexible, printed and large-area sensors and systems that conform to a wide range of surfaces to cater to the requirements of several applications. This trend will continue as the field of flexible, printed and disposable sensor technology is growing at an exponential rate. The development of printable and solution processable nanomaterials, and the development of additive manufacturing techniques offer new routes for smart sensor systems to intercept the global megatrends of wearable, disposable, and even implantable electronics, and the Internet of Things. IEEE FLEPS offers an excellent forum to discuss latest developments in the field shaping the future roadmaps for electronics with non-conventional materials and manufacturing technologies.

IEEE FLEPS 2019 offers a unique opportunity for the academic community to meet and network with industrial leaders in the field, and for industrialists to get an update on the most advanced technology in this field. We hope the atmosphere, breadth and depth of research topics combined with the quality of invited and contributed technical presentations will make FLEPS a 'must attend' event for you every year.

The technical program covers three full days of technical presentations following the tutorials session, which is organized the day before the conference with the aim of introducing the main topics and technology background. The 4 tutorials offered, this year are: (i) "An Introduction to Printable Electronics including Component Integration and Product Design for Printable Electronics", (ii) "A portable PPG/ECG combo system with Silicon Photomultipliers", (iii) "Moore's Law for Flexible Integrated Circuits" and (iii) "3D-printing: Technology, materials and selected applications". The tutorials are organized and chaired by Dr. Vincenzo Vinciguerra, ST Microelectronics. By design, this is a single-track symposium with high quality oral and poster presentations. Each presentation was carefully reviewed and selected by our Technical Program Committee and selected technical experts in the field. Each day starts with a keynote speaker of world-renowned fame who will provide a great overview of the most interesting advances that make this conference uniquely positioned in the field. Our 9 lecture sessions start with an invited talk of distinct invited speakers opening the floor to 4 regular talks, which are selected by the Technical Programme Committee following the peer review process. The contributed papers will be presented in oral (46 papers) and poster (51 papers) formats.

The Digest of Technical Papers for the IEEE FLEPS 2019 contains three-page versions of papers, provided to attendees in an electronic form. Most of the presented papers will be available in the IEEE Xplore after the symposium. Further, there is provision to record the presentations and the attendees will be able to download them for later use. All recorded presentations will be posted online for wider dissemination of the excellent research by the participants.

The Technical Program Committee will select 3 Best Student Papers from the oral and poster sessions. Vincenzo Vinciguerra will be chairing the Award Committee this year, with awards being announced on 9 July. Good luck to all presenting students!

We would like to express our special thanks to the Steering Committee, the Technical Program Committee, and many experts who contributed their time to evaluate submissions.

We thank the IEEE Sensors Council for sponsoring the IEEE FLEPS 2019 as well as our Patrons and Exhibitors. Our special thanks to Rachel Brockhoff, at Conference Catalysts, LLC for administrative support.

Finally, we thank all speakers, presenters, and attendees for making the IEEE FLEPS 2019 such a unique event. We hope that you find FLEPS 2019 professionally stimulating and enjoyable, and of course, we are looking forward to seeing you back next year for the FLEPS 2020.

Prof. Ravinder Dahiya
University of Glasgow, UK
Conference Chair

Dr. Luigi G. Occhipinti
University of Cambridge, UK
Technical Programme Chair

IEEE FLEPS 2019 Organizers

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Ravinder Dahiya, *University of Glasgow, Scotland, UK*

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Hanbin Ma, *Suzhou Institute of Biomedical Engineering and Technology (SIBET), China*

Aaron Voon-Yew Thean, *National University Singapore*

Praveen C Ramamurthy, *Indian Institute of Science, Bangalore, India*

Conference Management:

Conference Catalysts LLC, *United States*

IEEE FLEPS 2019 Track Chairs

Track 1: Emerging Materials for Flexible and Printable Sensors and Electronics

Aaron Voon-Yew Thean, *National University Singapore*

Zeynep Celik-Butler, *University of Texas, Arlington*

Track 2: High-throughput manufacturing of printed system (inc. 3D printing)

Sanjiv Sambandan, *University of Cambridge, UK*

Davide Deganello, *Swansea University, UK*

Track 3: Sensor Device Architectures and Smart Systems

Professor Arokia Nathan, *Cambridge Touch Technologies, UK*

Professor Takao Someya, *University of Tokyo, Japan*

Track 4: Low power electronics for Autonomous Sensors and IoT

Luigi Occhipinti, *University of Cambridge, UK*

Vincenzo Pecunia, *Soochow University, China*

Track 5: Disposable, Implantable and Biocompatible Sensor Technologies

Vassili Karanassios, *Waterloo University, Canada*

George Malliaras, *University of Cambridge, UK*

Track 6: Energy Harvesting, Storage and Actuation

Praveen C Ramamurthy, *Indian Institute of Science, Bangalore, India*

Simon Johnson, *Centre for Process and Innovation, UK*

Track 7: Hybrid Systems on foil, heterogenous integration and Packaging

Kourosh Kalantar-Zadeh, *University of New South Wales, Sydney, Australia*

Joachim Burghartz, *Institut für Mikroelektronik Stuttgart, Germany*

Track 8: Theoretical Studies and Modelling of Flexible, Stretchable and Printable Systems

Paolo Lugli, *University of Bolzano, Italy*

Hanbin Ma, *Suzhou Institute of Biomedical Engineering and Technology (SIBET), China*

Track 9: Emerging Applications (e.g. e-textile, IoT, smart cities, Health monitoring, soft robotics, etc.)

Felice Torrisi, *University of Cambridge, UK*

Benjamin C.K. Tee, *National University Singapore*

Technical Reviewers

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Kourosh Kalantar-Zadeh

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Paolo Lugli

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Best Student Paper Support



Exhibitors



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Exhibit hours will be from:
Monday, July 8th from 08:00 – 17:30 to Wednesday, July 10th from 08:00 – 15:00.

Social Program

Sunday, July 7th

Tutorial Lunch

Time: 13:00 – 14:00

Location: Cambridge Ballroom

**Available to tutorial registrants only*

Monday, July 8th

Conference Lunch

Time: 13:00 – 14:00

Location: Cambridge Ballroom

IEEE FLEPS 2019 Civic Reception

Time: 18:30 - 20:00

Location: City Chambers in Glasgow

82 George Square, Glasgow G2 1DU, UK

On Monday, July 8th from 18:30 to 20:00, IEEE FLEPS 2019 attendees are invited to the Welcome Reception at the City Chambers in Glasgow.

Support provided by:

**GLASGOW
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Tuesday, July 9th

Conference Lunch

Time: 13:00 – 14:00

Location: Cambridge Ballroom

Gala Dinner

Time: 18:30 - 22:00

Location: Marriott Glasgow

500 Argyle St, Glasgow G3 8RR, UK

See Page 8 for more information.

Wednesday, July 10th

Event: Conference Lunch

Time: 13:00 – 14:00

Location: Cambridge Ballroom

IEEE FLEPS Gala Dinner Informational Page

Menu & Evening Schedule July 9th

18:00 – 18:30

Bus loaded from The DoubleTree by Hilton Glasgow Central. There will be 3 trip opportunities for delegates to get their transportation to the dinner

Please meet in the hotel lobby by 18:00

18:15-18:45

Buses depart from The DoubleTree by Hilton Glasgow Central

19:00

Arrive to the Marriott Glasgow

19:00 - 19:30

Guests are greeted with a Welcome Drink upon arrival
Guests are welcomed to find their seats for the evening's events during this time

19:30 - 19:50

First Course Served

Roast Butternut Soup with Cajun Spice, Croutons and Parsley

19:50 - 20:20

Entrée Served

Garlic & Rosemary stuffed Chicken
Served with a Tomato Demi Glaze Sauce,
Sea Salt Roast Potatoes & Market Vegetables

20:20 - 21:20

Dessert Served:

Chocolate Torte, Served with a white chocolate Sauce

IEEE FLEPS 2019 Awards Ceremony

Best Student Paper Awards

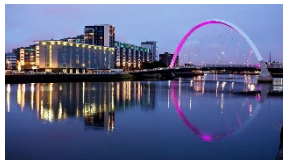


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21:30

Load buses back to The DoubleTree by Hilton Glasgow Central



Keynote Speakers

Monday, July 8th

08:30 – 09:30

“Stretchable nanomesh electronics for wearables and in vitro characterizations”

Professor Takao Someya

University of Tokyo, Japan

Abstract: Stretchable electronics are expected to open up a new class of applications ranging from wearable electronics for health-monitoring and human-machine interfaces, implantable electronics, and in vitro characterization. Wearable technology can enable continuous, long-term monitoring and lead to the personalization of medical care that can help people stay healthy and prevent more serious health problems from happening in the first place. In order to expand emerging applications of wearable technologies, soft biomedical sensors have attracted much attention recently. In order to minimize the discomfort of wearing sensors, it is highly desirable to use soft electronic materials particularly for devices that come directly into contact with the skin and/or biological tissues. Thanks to recent progress of soft electronics, intimate and conformal integration of electronics with the human skin can be created to continuously monitor health conditions. It can monitor small changes that occur very gradually over long periods and, therefore, have tremendous potential to drastically change the nature of the examination and treatment of medical conditions. In this talk, recent progress and outlook of wearables using stretchable devices will be reviewed. In particular, I report a newly developed hypoallergenic electronic sensor that can be worn on the skin continuously for a week without discomfort. It is so light and thin that users forget they even have it on. The elastic electrode constructed of breathable nanoscale meshes holds promise for the development of noninvasive on-skin devices that can monitor a person's health continuously over a long period. Then, similar nanomesh sensors is applied to in vitro characterization. These can monitor the field potential of cardiomyocytes on gel, while enabling them to move dynamically without interference.

Tuesday, July 9th

08:30 – 09:30

"Ultra-Low Power Sensor Interfaces for IoT"

Professor Arokia Nathan

Cambridge Touch Technologies, UK

Abstract: This talk will review the integration of oxides and fully printable organics for newly emerging application areas related to wearables and the Internet of Things. We will discuss the critical design considerations to show how device-circuit interactions should be handled and how compensation methods can be implemented for stable and reliable operation. In particular, the quest for low power becomes highly compelling in wearable devices. We will discuss transistor operation in the different regimes, and review device properties when operated in the deep sub-threshold regime or in near-OFF state, addressing the pivotal requirement of low supply voltage and ultralow power leading to potentially battery-less operation.

Keynote speakers

Wednesday, July 10th
08:30 – 09:30

"Fundamentals and applications of hybrid printed Electronics and how to integrate into flexible, stretchable and three-dimensional products."

Corne Rentrop

Project Leader, Hybrid Printed Electronics Group at the Holst Center, TNO, The Netherlands

Abstract: Hybrid printed electronics become more and more available to integrate electronics in specific form-factors at high volume and low costs. There is no shortage of hybrid printed electronics concept ideas and product prototypes related to automotive, healthcare, smart packaging and buildings. Also, the available production capability and functionality maturity for realizing these products are emerging enabling testing in an operational environment for end-users, interested in this technology.

The talk discusses the available manufacturing techniques for hybrid printed electronics comprising of state-of-the-art printing steps, electrical component assembly, post-processing steps, product integration steps and (electrical) characterisation methods.

The talk will be supplemented with manufacturing examples of high volume production prototypes at available pilot lines at the Holst Centre. On top of that we take a look at available methods for integrating electronics in 3D applications. In-mould electronics, and 3D printing are such foreseen technologies.

Invited Speakers

Monday, July 8th

10:00 – 11:30

A2L-A: Emerging Materials 1

“Hybrid Electronic Devices: Printing a Sensors on a Chip”

Davide Deganello

Swansea University, UK

Abstract: Through development of novel functional materials and advanced fabrication processes, functional printing offers exciting opportunities for the development of next-generation biomedical and electronic devices from large-area applications to higher resolution custom applications. Development of high resolution printing, such as by direct-write aerosol jet printing, provides new opportunities of hybrid integration between printed electronics and conventional silicon technologies. The presentation will focus on the “Printed-Sensor-on-Chip” platform and its fabrication challenge: thin film sensors accurately fabricated by AJ printing over the top surface and sides of an IC chip. Verified for humidity testing, the concept is envisaged to work as a platform for a wide range of applications, from signal processing, bio-sensing to energy storage.

11:30 – 13:00

A3L-A: High-throughput manufacturing

“An Advanced Application of Photonic Curing Tools: Photonic Soldering”

Kurt Schroder

NovaCentrix, USA

Abstract: Photonic curing as a non-equilibrium heating process has been widely established as suitable for printed electronics applications such as drying and sintering metal-based electrically-conducting inks, annealing CIS photovoltaic materials, and processing other coatings on structures that cannot withstand the high thermal load of a conventional oven. Photonic curing is likely to continue to enable innovation in processing coated thin films for applications ranging from displays, sensors, energy storage, and other applications of flexible-hybrid electronics (FHE). Importantly, new applications are being developed that take advantage of the advances in photonic curing tool capabilities. This talk will focus on a recent development called photonic soldering.

The development of flexible hybrid electronics requires an inexpensive, reliable and high throughput attachment technique for functional components onto printed circuits. The challenge faced with the current reflow technology is that many of the desired substrates cannot withstand the necessary temperatures required to reach the liquidus point of common solders. To overcome this limitation, conductive adhesive attachment techniques were developed but they lack the reliability of soldering. To circumvent the stated challenge posed by the substrates, a photonic soldering technique has been developed that takes advantage of the selective absorption of light to reach the liquidus temperature of conventional solders without significant heating of the underlying substrate. The short time the substrate spends at elevated temperatures may not be sufficient to damage the underlying substrate. This technique could work with conventional lead-free solders (e.g. SAC-305) and commercial packages (e.g. 402MM) or bare thinned dies on a variety of substrates, including PET, PEN as well as metallic foils. The photonic soldering technique is feasible for integration into high throughput roll-to-roll or sheet-to-sheet setups in a compact package using significantly less energy as the time to solder is only a few seconds versus several minutes for conventional reflow technology.

Invited Speakers

Monday, July 8th

14:00 – 15:30

A4L-A: Sensor Devices & Architectures 1

“Sensors Trends: Smaller, Cheaper, Smarter, Faster and Under Wireless Control”

Vassili Karanassios

University of Waterloo, Canada

Abstract: Arguably, the trends in sensor research, development and commercialization can be classified in five broad categories (not necessarily in the order they appear in the title). In this presentation, these trends will be briefly discussed using examples from the literature and from the authors' laboratory. Powering schemes (ranging from energy harvesting to self-powering) and power-management approaches will be outlined. Applicability and potential socio-economic impact will be briefly discussed, with particular emphasis on the application of future sensors in IoT (Internet of Things), in Industry 4.0 (and in the emerging but not yet well defined Industry 5.0), and in Society 5.0.

16:00 – 17:30

A5L-A: Low-power & Hybrid Systems

“Bespoke Machine Learning Processor Development Framework on Flexible Substrates”

Emre Ozer

Arm Research, Cambridge, UK

Abstract: This paper proposes a framework for the design of bespoke machine learning (ML) processors on flexible substrates (e.g. plastic) to address an important need in flexible and wearable applications – a processing engine of the flexible electronics applications. The proposed framework automates the design of bespoke ML processors on flexible substrates to reduce development time, and therefore the time-to-market.

Invited Speakers

Tuesday, July 9th

10:00 – 11:30

B2L-A: Disposable & Implantable Biosystems 1

“Human Gas Sensing Capsules for Diagnosing Gut Disorders”

Kourosh Kalantar-Zadeh

University of New South Wales, Sydney, Australia

Abstract: Ingestible sensors are rising as the next most important medical devices for monitoring of human disorders, providing invaluable information regarding different biomarkers of the gut. In this talk, the history of the development of ingestible gas sensing capsules will be presented. This gas sensing capsules have applications in diagnostics of gut disorders and assessing dietary impacts. These capsules leave the body after normal bowel transient and, during this time, transmit information about the gas profiles in different segments of the gut. The capsules consist of gas sensors, electronic circuits, small-sized harmless batteries and telecommunication components that operate within a safe commercial band. The capsules allow accurate measurement of the concentrations of vital gases of O₂, H₂ of CO₂ and also temperature. Animal and the first phase of human trials have been successfully completed and the public domain available outcomes of these trials will be presented in the talk. The observed phenomena using the capsule can potentially revolutionize fields of gastroenterology and food sciences.

11:30 – 13:00

B3L-A: Emerging Applications 1

“Low Power CMOS Inverters Based on Printable Inorganic Thin-Film Transistors”

Zheng Cui

Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences, China

Abstract: Low power electronics are typically achieved by CMOS circuits which require both p-type and n-type transistors. However, making CMOS electronics with solution type semiconductors has met great difficulties because no printable semiconductor materials are good at both p-type and n-type.

Invited speakers

Wednesday, July 10th

10:30 – 11:30

C2L-A: Emerging Materials 2

"Nanostructured films and polymer composites of Graphene and Two-dimensional Materials: electrical and mechanical properties and applications in wearable electronics"

Dr. Felice Torrì

Molecular Science Research Hub, Department of Chemistry, Imperial College London, UK

Abstract: Graphene and related 2D materials (GRMs) hold a great potential for flexible electronics and photonics for their novel electrical and optical properties, ideal for new lasers and wearable electronics. [1]. The production and deposition of thin films of GRM (fig.1a) from solutions or inks is extremely attractive for printed electronic devices, viable for flexible electronics. [2] GRM-based inks enable a large range of printed device and integration options, such as digital, lithographic printing and roll-to-roll coating, which are ideal to deposit patterned thin films. The exfoliation in liquid of layered bulk materials (such as graphite, MoS₂ crystals, etc.) is a scalable approach ideal to produce inks. However, currently the low yield of this process, results in a low concentration of dispersed GRMs. I will give a brief overview on the development of high-yield production GRM-based solutions and inks, suitable for several printing processes enabling GRM-based printable and flexible (opto)electronic devices. [3]. Then I will show how careful tuning of the surface interaction and GRM deposition process enables printed electronic and optoelectronic devices [4] from 2D material inks (fig.1b), such as Thin Film Transistors achieving electron mobility > 100 cm² V⁻¹ s⁻¹ at room temperature. [5] Finally, I will demonstrate how the biocompatible properties of graphene [6] and are suitable as neuron-interfacing electrodes, (fig.1c) preserving the neuronal activity. This paves the way to the fabrication of flexible graphene-based devices on plastics or textiles for medical applications, (fig.1d) such as biosensors and neuroprosthetics, whereby graphene electrodes interact efficiently with the cells without altering the cells behaviour [6].

11:30 – 13:00

C3L-A: Modelling and Simulation 1

"Design of Bendable High-Frequency Circuits Based on Short-Channel InGaZnO TFTs"

Niko Münzenrieder

Sensor Technology Research Centre, University Of Sussex, UK

Abstract: Conformable systems operated in close proximity to the human body, or fabricated on large-area plastic substrates enable new applications including smart implants, and electronic textiles. A unique requirement of flexible systems is the need to optimize their electrical and mechanical performance simultaneously. In particular, flexible sensor conditioning and transceiver circuits, insensitive to bending, are required. Thin-film transistors (TFTs) based on amorphous InGaZnO have the potential to enable such circuits.

Invited speakers

Wednesday, July 10th

14:00 – 15:30

C4L-A: Energy Harvesting & Storage Systems 1

“Energy Harvesting Power Supplies for Electronic Textiles”

Stephen Beeby

University of Southampton, UK

Abstract: Electronic textiles (e-textiles or smart fabrics) include smart, electronic functionality and a key challenge is supplying power. Existing solutions are battery powered using conventional rigid batteries that are incompatible with the feel and nature of the textile. Alternative power supplies using energy harvesting techniques could provide an alternative solution to supply power. Combining flexible energy harvesting techniques with textile electronics offers the potential for autonomous integrated e-textile solutions. This paper presents research at the University of Southampton towards printable flexible piezoelectric films, ferroelectret textiles, spray coated solar cells, fabric based inductive wireless power transfer and textile supercapacitors.

16:00 – 17:30

C5L-A: Emerging Application 2

“Engineering Organic Electronic Materials for the Development of Smart Textiles ”

Esma Ismailova

Department of Bioelectronics, Ecole Nationale Supérieure des Mines de Saint Etienne, CMP-EMSE, MOC, France

Abstract: In the 21st century, consumers are rapidly gaining access to a novel suite of wearable electronic devices such as smart watches, glasses and garments. These technologies promise both comfort and ease of use, as well as an access to a wealth of health-related information. Advances in the field of electronic textiles, and recent achievements in organic electronics, have enabled the development of new flexible and conformable technologies that can perform the same sensing as current solid-state devices, for a fraction of the cost.

Tutorials

Sunday, July 7th
10:00 – 11:15

"An Introduction to Printable Electronics including Component Integration and Product Design for Printable Electronics"

Room: Imperial Ballroom

Instructor: Dr. Simon Johnson, *Chief Technologist within Printed Electronics, Centre for Process Innovation, UK*

About the Course

Aims:

- To introduce the field of Printable Electronics and its applications
- To discuss the techniques used for circuit assembly and the characteristics of surface mount technology for flexible assemblies
- To provide an understanding of the design process for printable electronic circuits

Course Contents:

- Characteristics of Printable Electronics
- Flexible and ultra-thin form factors
- Applications of Printable Electronics
- Printable Electronics and the Internet of Things
- Printed Electronic Components including:
 - Printed sensors, Photovoltaic devices, Displays and light sources, Batteries and energy storage, transistors and Integrated circuits
- Assembly Techniques for Printable Electronics
- Automation and scale up for Manufacture
- The product design process for printable electronic products
- Case study – Smart Label for the Pharmaceutical Industry

Tutorials

Sunday, July 7th
11:45 – 13:00

"A portable PPG/ECG combo system with Silicon Photomultipliers"

Room: Imperial Ballroom

Instructor: Prof. Alessandro Busacca, *University of Palermo, Italy*

About the Course

In this tutorial we show how optical sensors can be exploited in order to manufacture a conformable system able to monitor the arterial stiffness by means of a fully optical technique, which is the photoplethysmography PPG. We show how a PPG signal can be usefully monitored by exploiting also the ECG signals. In the tutorial, after an introduction on the PPG/ECG combined system, developed within the ASTON!SH ECSEL JU EU project, we proceed with a demo-live of a PPG/ECG portable system.

In details, we present a portable PPG/ECG combo system (Fig. 1) developed by the LOOX (Laboratory of Optics and Optoelectronic) of the University of Palermo, Italy. The system supports the synchronous acquisition of 8 channels (5 PPG + 3 ECG leads) with 24-bit resolution, a sampling rate of 1 kSPS and is capable to visualize, in real-time, the following physiological parameters: heart rate, ECG R-R intervals or PPG pulse-pulse interval, Pulse Arrival Time, Pulse Transit Time, Pulse Wave velocity and breathing rate. The visualization is achieved through an appositely developed Graphical User Interface (Fig. 2). The physiological parameters can be plotted in real time and saved for offline post-processing.

Each PPG probe includes a Silicon Photomultiplier (SiPM) detector, provided by STMicroelectronics, and a 735/850 nm Bi-Color LED. The functional parts of the system are: the Analog Front-End (Texas Instruments ADS1298, designed for Biopotential Measurements), the circuitry to drive the LEDs of the probes (employing an I2C interface), an STM32 microcontroller and the power supply circuitry. The system also includes USB and Bluetooth interfaces to transmit (both wired and wirelessly) the acquired data to the PC and is battery operated using standard AA batteries.

Tutorials

Sunday, July 7th
14:00 – 15:15

"Moore's Law for Flexible Integrated Circuits"

Room: Imperial Ballroom

Instructor: Dr. Florian de Roose, *IMEC (B), Belgium*

About the Course

Thin-film transistors (TFTs) are currently the dominant technology implemented as switching circuits in flat-panel displays and are promising candidates for Internet of Things (IoT) applications in near future. TFTs can be realized at low process temperatures, enabling direct manufacturing on ultrathin, flexible and large area substrates paving the way for seamless integration in everyday items. As the know-how on this flexible TFT technology increases (both in technology and design), more complex and denser structures are recently demonstrated for several Application-Specific Integrated Circuits (ASIC) with flexible TFTs. Thereby, thin-film transistor technologies follow a similar trend of increasing circuit complexity compared to conventional silicon CMOS technology.

In this tutorial talk, we will start by introducing three main TFT technologies currently available in several display and/or flexible circuit fabs: p-type organic TFTs, n-type metal-oxide TFTs and complementary low-temperature poly-silicon TFTs. We will dive into the advantages and disadvantages of each individual technology targeting flexible circuit applications and discuss their specific design challenges. The focus to solve these design challenges is the implementation of robust and fast switching logic gates at low power consumption. Finally, we will present two specific design cases towards large-scale integrated flexible circuits, namely a flexible 8-bit microprocessor and an ISO14443-A compliant NFC barcode tag [1]. Although these technologies today exhibit micrometer-size channel lengths, we will evaluate the impact of scaling for such flexible transistor technologies (similar as Moore's law for Si CMOS) to enable future IoT applications.

Tutorials

Sunday, July 7th
15:45 – 17:00

"3D-printing: Technology, materials and selected applications"

Room: Imperial Ballroom

Instructors: Vassili Karanassios, *Waterloo University, Canada*

About the Course

During the last several years, 3D printing has been receiving significant attention in the scientific literature and the popular press. It has also generated exciting business interests and prospects. To many, 3D printing (in many cases using polymeric materials) is a **transformative** technology capable of impacting many areas of experimental Science, of Engineering, of Medicine (including dentistry), and of fabrication and manufacturing technology (to name but a few). In addition, 3D printing has often been described as a technology that has the potential to alter rapid prototyping (an early publication in reference [1]) and to influence (if not **disrupt**) traditional methods of manufacturing. In fact, the capability of 3D printing to make personalized (i.e., one-of-a-kind) items on-demand may offer the necessary stepping stones for the implementation of the emerging **Industry 4.0**, and of the over the horizon **Industry 5.0** and of **Society 5.0**.

The aim of this tutorial is to provide an introduction to 3D-printing and to highlight potential future directions.

The content of this tutorial is (roughly) divided into five parts:

1. 3D printing technologies.
2. Materials for 3D-printing.
3. Comparison of technologies, capabilities and materials used for 3D printing.
4. Selected applications of 3D printing, with examples drawn from the Engineering and the Scientific literature (with many) from the author's laboratory.
5. Future directions of 3D printing technology, the potential impacts of this technology on **IoT**, on **Industry 4.0** and (**potentially**) on **Industry 5.0** and of its capability to influence (if not enable) **Society 5.0 approaches** will be discussed. General comments on future societal and economic impacts of 3D printing will be made.

Sunday, July 7

07:00 – 17:30

Tutorial Registration ***Those not registered to attend tutorials may begin checking in after 8:30 AM.*

Room: Ballroom Royer

10:00 – 11:15

Tutorial 1: "An Introduction to Printable Electronics including Component Integration and Product Design for Printable Electronics"

Instructor: Dr. Simon Johnson, *Chief Technologist within Printed Electronics, Centre for Process Innovation, UK*

Room: Imperial Suite

Session Chair: Dr. Vincenzo Vinciguerra, *STMicroelectronics, Italy*

11:15 – 11:45

Coffee Break & Networking

Room: Cambridge Suite

11:45 – 13:00

Tutorial 2: "A portable PPG/ECG combo system with Silicon Photomultipliers"

Instructor: Prof. Alessandro Busacca, *University of Palermo, Italy*

Room: Imperial Suite

Session Chair: Dr. Vincenzo Vinciguerra, *STMicroelectronics, Italy*

13:00 – 14:00

Lunch

Room: Cambridge Suite

14:00 – 15:15

Tutorial 3: "Moore's Law for Flexible Integrated Circuits"

Instructor: Dr. Florian de Roose, *IMEC (B), Belgium*

Room: Imperial Suite

Session Chair: Dr. Vincenzo Vinciguerra, *STMicroelectronics, Italy*

15:15- 15:45

Coffee Break & Networking

Room: Cambridge Suite

15:45 – 17:00

Tutorial 4: "3D-printing: Technology, materials and selected applications"

Instructors: Vassili Karanassios, *Waterloo University, Canada*

Room: Imperial Suite

Session Chair: Dr. Vincenzo Vinciguerra, *STMicroelectronics, Italy*

Monday, July 8

07:30 – 17:30

Registration

Room: Ballroom Foyer

08:15 – 08:30

Welcome and Introduction

Room: Imperial Suite

08:30 – 09:30

Keynote Speaker: Professor Takao Someya, *University of Tokyo, Japan*

Room: Imperial Suite

“Stretchable nanomesh electronics for wearables and in vitro characterizations”

Professor Takao Someya

University of Tokyo, Japan

09:30 – 10:00

Coffee Break & Exhibits

Room: Cambridge Suite

10:00 – 11:30

A2L-A: Emerging Materials 1

Room: Imperial Suite

Session Chair: Luigi Occhipinti, *University of Cambridge, UK*

10:00

INVITED TALK: HYBRID ELECTRONIC DEVICES: PRINTING A SENSOR ON A CHIP

Davide Deganello

Swansea University, UK

10:30

HALF-VOLT IGZO FLEXIBLE THIN-FILM TRANSISTORS WITH E-BEAM DEPOSITED AL₂O₃ GATE DIELECTRIC

Dinesh Kumar, Aly Abdou, Jeff Kettle

Bangor University, United Kingdom

10:45

FLEXIBLE AND MULTI-FUNCTIONAL GRAPHENE SENSOR PLATFORM

Altynay Kaidarova, Abeer Almoudi, Renad Allagani, Marco Marengo, Mohammed Khan, Ulrich Buttner, Carlos Duarte, Jurgen Kosel

King Abdullah University of Science and Technology, Saudi Arabia

11:00

OPPORTUNITY OF METALLIC GLASS IN SOFT ELECTRONICS

Minhyun Jung^{1}, Dongseuk Kim^{2}, Kyungkwan Kim^{3}, Changjin Yun^{3}, Kungwon Rhie^{3}, Sanghun Jeon^{1}

^{1}KAIST, Korea; ^{2}Korea Research Institute of Standards and Science, Korea; ^{3}Korea University, Korea

Monday, July 8

11:15

SCREEN-PRINTABLE COLORIMETRIC SENSORS FOR THE MONITORING OF TOXIC GASES IN AMBIENT AIR

Laura Engel{1}, *Karina Tarantik*{1}, *Ismael Benito-Altamirano*{2}, *Carolín Pannek*{1}, *Daniel Prades*{2}, *Jürgen Wöllenstein*{1}
{1}Fraunhofer-Institut für Physikalische Messtechnik IPM, Germany; {2}Universitat de Barcelona, Spain

11:30 – 13:00

A3L-A: High-throughput Manufacturing

Room: Imperial Suite

Session Chair: Sanjiv Sambandan, *University of Cambridge*

11:30

INVITED TALK: AN ADVANCED APPLICATION OF PHOTONIC CURING TOOLS: PHOTONIC SOLDERING

Kurt Schroder, *Vahid Akhavan**, *Rob Hendriks*, *Nikhil Pillai*, *Stan Farnsworth*
NovaCentrix, United States

12:00

FLEXIBLE DISPENSE-PRINTED ELECTROCHEMICAL BIOSENSOR FOR AFLATOXIN M1 DETECTION EMPLOYING NAOH AND OXYGEN PLASMA ELECTRODE PRE-TREATMENT

Biresaw Demelash Abera, *Aniello Falco*, *Pietro Ibba*, *Giuseppe Cantarella*, *Luisa Petti*, *Paolo Lugli*
Libera Università di Bolzano, Italy

12:15

NANOJET PRINTED COPLANAR WAVEGUIDES ON FLEXIBLE POLYIMIDE SUBSTRATE UP TO 24 GHZ

Konstantin Lomakin, *Markus Ankenbrand*, *Mark Sippel*, *Jörg Franke*, *Klaus Helmreich*, *Gerald Gold*
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

12:30

CHARACTERIZING THE ELECTRICAL PROPERTIES OF ANISOTROPIC, 3D-PRINTED CONDUCTIVE SHEETS

Alexander Dijkshoorn, *Martijn Schouten*, *Gerjan Wolterink*, *Remco Sanders*, *Gijs Krijnen*
University of Twente, Netherlands

12:45

3D PRINTED INTERCONNECTS ON BENDABLE SUBSTRATES FOR 3D CIRCUITS

Habib Nassar, *Abhilash Pullanchiyodan*, *Mitradip Bhattacharjee*, *Ravinder Dahiya*
University of Glasgow, United Kingdom

13:00 – 14:00

Lunch

Room: Cambridge Suite

Monday, July 8

14:00 – 15:30

A4L-A: Sensor Devices & Architectures 1

Room: Imperial Suite

Session Chair: Kourosh Kalantar-Zadeh, *University of New South Wales, Sydney, Australia*

14:00

INVITED TALK: SENSORS TRENDS: SMALLER, CHEAPER, SMARTER, FASTER AND UNDER WIRELESS CONTROL

Vassili Karanassios

University of Waterloo, Canada

14:30

ACTIVE-MATRIX IGZO ARRAY WITH PRINTED THERMISTOR FOR LARGE-AREA THERMAL IMAGING

*Jan-Laurens van der Steen, Laurens Peters, Edsger Smits, Peter Zalar, Gerwin Gelinck
Holst Centre, TNO, Netherlands*

14:45

MICRO-STRAIN AND TEMPERATURE SENSORS FOR SPACE APPLICATIONS WITH GRAPHITE-PDMS COMPOSITE

Oppili Prasad{1}, Sreelal Pillai{2}, Sanjiv Sambandan{1}

{1}Indian Institute of Science, India; {2}Indian Space Research Organization, India

15:00

BOOSTING DIRECT X-RAY DETECTION IN ORGANIC THIN FILMS BY SMALL MOLECULES TAILORING

*Andrea Ciavatti{2}, Laura Basirico{2}, Ilaria Fratelli{2}, Stefano Lai{3}, Piero Cosseddu{1},
Annalisa Bonfiglio{3}, John Anthony{4}, Beatrice Fraboni{2}*

*{1}Università degli Studi di Cagliari, Italy; {2}University of Bologna, Italy; {3}University of Cagliari,
Italy; {4}University of Kentucky, United States*

15:15

FULLY PRINTED CPW-BASED MICROWAVE HUMIDITY SENSOR IN PHASE SHIFTING PARADIGM

Guy Ayissi Eyebe, Benoît Bideau, Éric Loranger, Frederic Domingue

Université du Québec à Trois-Rivières, Canada

15:30 – 16:00

Coffee Break & Exhibits

Room: Cambridge Suite

Monday, July 8

16:00 – 17:30

A5L-A: Low-power & Hybrid Systems

Room: Imperial Suite

Session Chair: Vincenzo Pecunia, *Soochow University, China*

16:00

INVITED TALK: BESPOKE MACHINE LEARNING PROCESSOR DEVELOPMENT FRAMEWORK ON FLEXIBLE SUBSTRATES

Emre Ozer{1}, Jędrzej Kufel{1}, John Biggs{1}, Gavin Brown{3}, James Myers{1}, Anjit Rana{2}, Antony Sou{2}, Catherine Ramsdale{2}

{1}Arm, United Kingdom; {2}PragmatlC, United Kingdom; {3}University of Manchester, United Kingdom

16:30

LOW-VOLTAGE HIGH-TRANSCONDUCTANCE DINAPHTHO-[2,3-B:2',3'-F]THIENO [3,2-B]THIOPHENE (DNFT) TRANSISTORS ON POLYETHYLENE NAPHTHALATE (PEN) FOILS

Amayikai A. Ishaku, Afra Al Ruzaiqi, Helena Gleskova

University of Strathclyde, United Kingdom

16:45

"WEAR AND FORGET" PATCH FOR AMBIENT ASSISTED LIVING

Dilek Ozgit{3}, Tim Butler{1}, Pelumi Oluwasanya{2}, Luigi Occhipinti{2}, Pritesh Hiralal{3}

{1}CITC Ltd, United Kingdom; {2}University of Cambridge, United Kingdom; {3}Zinergy UK Ltd, United Kingdom

17:00

OLED-OPD MATRIX FOR FLUORESCENCE SENSING ON A SINGLE FLEXIBLE SUBSTRATE

Nicole Schneidewind, Markus Köpke, Janek Buhl, Yolande Murat, Martina Gerken

Kiel University, Germany

17:15

CHARACTERIZATION OF THIN-FILM TEMPERATURE SENSORS AND ULTRA-THIN CHIPS FOR HYSIF INTEGRATION

Mourad Elsobky, Alessandro Ottaviani, Mohammed Alomari, Zili Yu, Thomas Deuble, Joachim N. Burghartz

Institut für Mikroelektronik Stuttgart, Germany

18:30 – 20:00

Welcome Reception

Room: *City Chambers in Glasgow*

82 George Square, Glasgow G2 1DU, UK

Tuesday, July 9

07:30 – 17:30

Registration

Room: Ballroom Foyer

08:30 – 09:30

Keynote Speaker: Professor Arokia Nathan, *Cambridge Touch Technologies, UK*

Room: Imperial Suite

“Ultra Low Power Sensor Interfaces for IoT”

Professor Arokia Nathan

Cambridge Touch Technologies, UK

09:30 – 10:00

Coffee Break & Exhibits

Room: Cambridge Suite

10:00 – 11:30

B2L-A: Disposable & Implantable Biosystems 1

Room: Imperial Suite

Session Chair: Vassili Karanassios, *University of Waterloo, Canada*

10:00

INVITED TALK: HUMAN GAS SENSING CAPSULES FOR DIAGNOSING GUT DISORDERS

Kourosh Kalantar-Zadeh

University of New South Wales, Australia

10:30

HIGHLY SENSITIVE SCREEN PRINTED STRAIN GAUGE FOR MICRO-STRAIN DETECTION

Armesh Bose, Xingzhe Zhang, Dinesh Maddipatla, Simin Masihi, Masoud Panahi, Binu Narakathu, Bradley Bazuin, Massood Atashbar

Western Michigan University, United States

10:45

PRINTED TEMPERATURE SENSOR BASED ON GRAPHENE OXIDE/PEDOT:PSS

Mahesh Soni, Mitradip Bhattacharjee, Libu Manjakkal, Ravinder Dahiya

University of Glasgow, United Kingdom

11:00

MICRODROPLET BASED ORGANIC VAPOUR SENSOR ON A DISPOSABLE GO-CHITOSAN FLEXIBLE SUBSTRATE

Mitradip Bhattacharjee, Anastasios Vilouras, Ravinder Dahiya

University of Glasgow, United Kingdom

11:15

FLEXIBLE PH SENSOR FOR WIRELESS MONITORING OF THE HUMAN SKIN FROM THE MEDIUM DISTANCES

Simone Nappi{2}, Vincenzo Mazzaracchio{2}, Luca Fiore{2}, Fabiana Arduini{2}, Gaetano Marrocco{1}

{1}Università degli Studi di Roma Tor Vergata, Italy; {2}University of Tor Vergata Rome, Italy

Tuesday, July 9

11:30 – 13:00

B3L-A: Emerging Applications 1

Room: Imperial Suite

Session Chair: Hanbin Ma, *Axcel Tech Ltd., UK*

11:30

INVITED TALK: LOW POWER CMOS INVERTERS BASED ON PRINTABLE INORGANIC THIN-FILM TRANSISTORS

Qiqi Xu, Manman Luo, Jianwen Zhao, Zheng Cui

Suzhou Institute of Nanotech and Nanobionics, Chinese Academy of Sciences, China

12:00

PRINTABLE PIEZORESISTIVE CARBON FORMULATION FOR STRETCH AND FLEX SENSORS IN E-TEXTILE APPLICATIONS

Meijing Liu, Sasikumar Arumugam, Yi Li, Sheng Yong, Neil White, Kai Yang, Stephen Beeby
University of Southampton, United Kingdom

12:15

LABEL-FREE DETECTION OF DOPAMINE USING APTAMER ENHANCED ORGANIC-ELECTROLYTE GATED FET SENSOR

Roslyn Massey^{2}, Evelyn Morin^{2}, Maria Derosa^{1}, Ravi Prakash^{1}
^{1}Carleton University, Canada; ^{2}Queen's University, Canada

12:30

FLEXIBLE AND WEARABLE ULTRASONIC SENSOR FOR ASSESSMENT OF SKELETAL MUSCLE CONTRACTILE PROPERTIES

Ibrahim AlMohimeed^{2}, Yuu Ono^{1}

^{1}Carleton University, Canada; ^{2}Carleton University, Majmaah University, Canada

12:45

IMPACT OF TI INTERFACIAL LAYER ON RESISTIVE SWITCHING CHARACTERISTICS AT SUB- μ A CURRENT LEVEL IN SIOX-BASED FLEXIBLE CROSS-POINT RRAM

Subhranu Samanta, Zhang Panpan, Kaizhen Han, Gong Xiao, Sandipan Chakraborty, Yida Li, Xuanyao Fong

National University of Singapore, Singapore

13:00 – 14:00

Lunch

Room: Cambridge Suite

14:00 – 15:00

B4LA: Industry Workshop & Panel Discussion

Room: Imperial Suite

Session Chair: Steve Beaumont, *University of Glasgow, UK*

IEEE FLEPS will have Industry panel discussion focussing on the commercialization throughout the supply chain of flexible and printed systems. The panel will have members from leading companies from all over the world.

Tuesday, July 9

15:00 – 17:30

Coffee Break & Exhibits

Room: Cambridge Suite

15:00 – 17:30

Poster Session

Room: Lord Provost Suite

Session Chairs: Libu Manjakkal, *University of Glasgow*

Ensieh S. Hosseini, *University of Glasgow*

P-1

ELECTRICAL CHARACTERIZATION OF STRETCHABLE PRINTED LIQUID METAL INTERCONNECTS UNDER REPEATED CYCLIC LOADING

Callen Votzke, Kyle Clocker, Yigit Mengüç, Matthew Johnston

Oregon State University, United States

P-2

AEROSOL JET PRINTED WSE₂ BASED RRAM ON KAPTON SUITABLE FOR FLEXIBLE MONOLITHIC MEMORY INTEGRATION

Yida Li, Maheswari Sivan, Jessie Xuhua Niu, Hasita Veluri, Evgeny Zamburg, Jinfeng Leong, Umesh Chand, Subhranu Samanta, Xinghua Wang, Xuewei Feng, Yunshan Zhao, Aaron Voon-Yew Thean

National University of Singapore, Singapore

P-3

CONVENTIONAL VERSUS FLEXIBLE SUBSTRATES FOR DYE SENSITIZED AND PEROVSKITE TYPE PHOTO VOLTAIC SOLAR CELLS

Junaid Ur Rehman, Masud Chowdhury

University of Missouri Kansas City, United States

P-4

FLEXIBLE CIRCUITS FOR MOISTURE MEASUREMENT IN CYLINDRICAL TIMBER OF WOOD

Diego Dias Dos Reis, Fernando Castaldo, Sérgio Pichorim

Universidade Tecnológica Federal do Paraná, Brazil

P-5

SENSITIVITY, STABILITY, AND SPRING CONSTANTS OF PAPER BASED WEIGHING BALANCES

Connaire McCann, Hamza Shakeel

Queen's University Belfast, United Kingdom

P-6

SUPER-CAPACITORS AND OTHER FIBER-SHAPED BATTERIES AS ENERGY STORAGE DEVICES FOR FLEXIBLE ELECTRONIC DEVICES

Junaid Ur Rehman, Masud Chowdhury

University of Missouri Kansas City, United States

P-7

INTERCONNECTS FOR FLEXIBLE AND PRINTED ELECTRONIC APPLICATIONS

Junaid Ur Rehman, Masud Chowdhury

University of Missouri Kansas City, United States

Tuesday, July 9

P-8

NANOCOMPOSITE ZN₂SNO₄/SNO₂ THICK FILMS AS A HUMIDITY SENSING MATERIAL

Maria Nikolic{2}, Milena Dojcinovic{2}, Zorka Vasiljevic{1}, Miloljub Lukovic{2}, Nebojsa Labus{1}
{1}Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia;
{2}University of Belgrade, Serbia

P-9

UV CURED PVP GATE DIELECTRIC FOR FLEXIBLE ORGANIC FIELD EFFECT TRANSISTORS

Vivek Raghuvanshi, Deepak Bharti, Ajay Kumar Mahato, Ishan Varun, Shree Prakash Tiwari
Indian Institute of Technology Jodhpur, India

P-10

DEVELOPING A 3D PRINTABLE ELECTRET MATERIAL FOR SENSING APPLICATIONS

Oluwaseun Omoniyi, Ben Tiller, Richard O'Leary, James Windmill
University of Strathclyde, United Kingdom

P-11

DEVELOPMENT OF A FLUORINATED GRAPHENE-BASED FLEXIBLE HUMIDITY SENSOR

Sajjad Hajian{2}, Xingzhe Zhang{2}, Dinesh Maddipatla{2}, Binu Narakathu{2}, Anthony Hanson{2}, Richard Blair{1}, Massood Atashbar{2}
{1}University of Central Florida, United States; {2}Western Michigan University, United States

P-12

RFID BASED BATTERY-FREE SENSOR NODE FOR SMART RAILWAY APPLICATION USING 3D-PRINTING TECHNOLOGY

Yick Yu Chim, M. H. F. Leung, Y.Q Ni, Eric. C. L. Tsang
Hong Kong Polytechnic University, Hong Kong

P-13

A FLEXIBLE DIFFERENTIAL TEMPERATURE SENSOR FOR WEARABLE ELECTRONICS APPLICATIONS

Shawkat Ali{1}, Jinho Bae{2}, Amine Bermak{1}
{1}Hamad Bin Khalifa University, Qatar; {2}Jeju National University, Korea

P-14

A PVDF/AU/PEN MULTIFUNCTIONAL FLEXIBLE HUMAN-MACHINE INTERFACE FOR 2D POSITION, FORCE, HOVER, SURFACE CURVATURE SENSING AND ENERGY HARVESTING

Yanning Dai, Shuo Gao
Beihang University, China

P-15

PRINTED COIL ON QUARTZ CRYSTAL RESONATOR SENSOR FOR ELECTROMAGNETIC CONTACTLESS INTERROGATION

Marco Baù, Marco Demori, Marco Ferrari, Vittorio Ferrari
University of Brescia, Italy

P-16

DETECTORS & LIGHT-SOURCES FOR OPTICAL SPECTROMETRY: FROM A 3D-PRINTED LIGHT-SOURCE TO A SELF-POWERED SENSOR FABRICATED ON A FLEXIBLE POLYMERIC SUBSTRATE, & FROM THERE ON TO AN IOT-ENABLED SMART SYSTEM

Amy Hall, Grace Xuan Kong, Vassili Karanassios
University of Waterloo, Canada

Tuesday, July 9

P-17

LASER-ASSISTED PATTERNING OF A FLEXIBLE MICROPLASMA DISCHARGE DEVICE FOR HEAVY METAL AND SALT DETECTION IN AMBIENT AIR

*Arnesh Bose, Dinesh Maddipatla, Binu Narakathu, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States*

P-18

FLEXIBLE PASSIVE TEMPERATURE SENSOR LABEL WITH CONTACTLESS INTERROGATION

*Marco Bau, Marco Ferrari, Vittorio Ferrari
University of Brescia, Italy*

P-19

A IGZO-BASED LIGHT-ADDRESSABLE POTENTIOMETRIC SENSOR ON A PET SUBSTRATE

*Chun Hui Chen, Chia-Ming Yang
Chang Gung University, Taiwan*

P-20

CHARACTERIZATION OF BIOCHAR-BASED ECO-FRIENDLY PRESSURE SENSORS

*Federico Donati, Alberto Giovanelli, Davide Brunelli
University of Trento, Italy*

P-21

FLEXIBLE PIEZORESISTIVE PDMS METAL-THIN-FILM SENSOR-CONCEPT FOR STIFFNESS EVALUATION OF SOFT TISSUES

*Benjamin Sittkus, Rui Zhu, Ulrich Mescheder
Furtwangen University, Germany*

P-22

NOVEL PRINTED CARBON NANOTUBES BASED RESISTIVE HUMIDITY SENSORS

*Xingzhe Zhang, Vikram Turkani, Sajjad Hajian, Arnesh Bose, Dinesh Maddipatla, Anthony Hanson, Binu Narakathu, Massood Atashbar
Western Michigan University, United States*

P-23

REDUCED GRAPHENE OXIDE DECORATED WITH METALS NANOPARTICLES ELECTRODE AS ELECTROCHEMICAL SENSOR FOR DOPAMINE

*Bernardo Patella, Alessia Sortino, Giuseppe Aiello, Carmelo Sunseri, Rosalinda Inguanta
University of Palermo, Italy*

P-24

DEVELOPMENT OF A FLEXIBLE FORCE SENSOR USING ADDITIVE PRINT MANUFACTURING PROCESS

*Dinesh Maddipatla, Xingzhe Zhang, Arnesh Bose, Simin Masihi, Masoud Panahi, Valliammai Palaniappan, Binu Narakathu, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States*

P-25

MICROCHANNEL BASED FLEXIBLE DYNAMIC STRAIN SENSOR

*Mitradip Bhattacharjee, Mahesh Soni, Ravinder Dahiya
University of Glasgow, United Kingdom*

Tuesday, July 9

P-26

FLEXIBLE PIEZOELECTRIC HARVESTER FOR HUMAN FINGERS: MEASUREMENTS AND APPLICATIONS

*Alfiero Leoni, Iolanda Ulisse, Vincenzo Stornelli, Giuseppe Ferri
University of L'Aquila, Italy*

P-27

RAPID PROTOTYPING OF A TUNABLE AND COMPACT MICROSTRIP ANTENNA BY LASER MACHINING FLEXIBLE COPPER TAPE

*Simin Masihi, Masoud Panahi, Arnesh Bose, Dinesh Maddipatla, Anthony Hanson, Binu Narakathu, Bradley Bazuin, Massood Atashbar
Western Michigan University, United States*

P-28

3D INTEGRATED ELECTRONICS WITH LAYER BY LAYER PRINTING OF NWS

*Fengyuan Liu, Adamos Christou, Ravinder Dahiya
University of Glasgow, United Kingdom*

P-29

RELIABILITY INVESTIGATION OF VIA-BRIDGES FOR FLEXIBLE ELECTRONICS

*João Neto, Ayoub Zumeit, William Navaraj, Ravinder Dahiya
University of Glasgow, United Kingdom*

P-30

COMPACT MODELING OF STRETCHABLE PRINTED LIQUID METAL ELECTRICAL INTERCONNECTS

*Kyle Clocker, Callen Votzke, Yigit Mengüç, Matthew Johnston
Oregon State University, United States*

P-31

3D RECOGNITION OF OBSTACLES USING A VIBRISSA-LIKE TACTILE SENSOR

*Lukas Merker^{2}, Joachim Steigenberger^{2}, Carsten Behn^{1}
^{1}Schmalkalden University of Applied Sciences, Germany; ^{2}Technische Universität Ilmenau, Germany*

P-32

AN INKJET-PRINTED STRAIN SENSOR WITH A CARBON-SILVER-POLYIMIDE TOPOLOGY

*Ying Yi, Shawkat Ali, Bo Wang
Hamad Bin Khalifa University, Qatar*

P-33

ADAPTING A PIFA ANTENNA STRUCTURE AS A STRAIN SENSOR

*Jeevan Persad, Sean Rocke
University of The West Indies, Trinidad and Tobago*

P-34

DESIGN OF A HIGHLY SENSITIVE, FLEXIBLE AND STRETCHABLE TACTILE SENSOR FOR ELECTRONIC SKIN APPLICATIONS

*İrem Attar, Kadir Serhat Altıntig, Ibrahim Bozyel, Dincer Gokcen
Hacettepe University, Turkey*

P-35

FLEXIBLE CAPACITIVE UV SENSOR FOR FUTURE WEARABLES

*Tridib Saha, Tay Quan Lin, Ajay Achath Mohanan
Monash University Malaysia, Malaysia*

Tuesday, July 9

P-36

TEXTILE BASED FERROELECTRET FOR FOOT PRESSURE SENSOR

*Junjie Shi, Stephen Beeby
University of Southampton, United Kingdom*

P-37

FLEXIBLE MULTI-MODAL SENSOR FOR ELECTRONIC SKIN

*Minhyun Jung{2}, Sujaya Kumar Vishwanath{2}, Jihoon Kim{3}, Dae-Kwan Ko{1}, Myung-Jin Park{1}, Soo-Chul Lim{1}, Sanghun Jeon{2}
{1}Dongguk University, Korea; {2}KAIST, Korea; {2}KAIST, India; {3}Kongju National University, Korea*

P-38

FLEXIBLE FORCE SENSORS EMBEDDED IN OFFICE CHAIR FOR MONITORING OF SITTING POSTURES

*Amayikai A. Ishaku{2}, Aris Tranganidas{2}, Slavomír Matúška{3}, Róbert Hudec{3}, Graeme McCutcheon{1}, Lina Stankovic{2}, Helena Gleskova{2}
{1}Ramboll UK, United Kingdom; {2}University of Strathclyde, United Kingdom; {3}University of Žilina, Slovakia*

P-39

CONDUCTIVE TEXTILES VIA ELECTROLESS DEPOSITION FOR FLEXIBLE ELECTRONICS

*Waleri Root, Noemí Aguiló-Aguayo, Justus Landsiedel, Thomas Bechtold, Tung Pham
University of Innsbruck, Austria*

P-40

AN ALL-FLEXIBLE SENSING SOLE FOR LEGGED ROBOTS

*Lisa-Marie Faller, Christian Stetco, Tobias Mitterer, Hubert Zangl
Alpen-Adria-Universität Klagenfurt, Austria*

P-41

SPRAY COATED TEXTILE SOLAR CELLS

*Sasikumar Arumugam, Yi Li, Stephen Beeby
University of Southampton, United Kingdom*

P-42

FOUR-PHASE FLOWER-SHAPE FLEXIBLE STATOR WINDING OF MICRO-MOTOR

*Qiang Shen, Xiaokang Yuan, Honglong Chang
Northwestern Polytechnical University, China*

P-43

INTEGRATION OF TEMPERATURE SENSORS IN FABRICS

*Abiodun Komolafe, Russel Torah, Helga Nunes-Matos, Michael Tudor, Stephen Beeby
University of Southampton, United Kingdom*

P-44

TEXTILE TOUCH-SENSOR ARRAY BASED ON CIRCULAR AND NON-CIRCULAR POLYMER OPTICAL FIBERS

*Jan Kallweit{2}, Christian-Alexander Bunge{1}, M. Al-Houri{1}, Benjamin Mohr{3}, Artūrs Bērziņš{2}, Christian Graubeger{2}, Putu Teguh Satria Adi{2}, Thomas Gries{2}
{1}Institut für Kommunikationstechnik at Hochschule für Telekommunikation Leipzig, Germany; {2}Institut für Textiltechnik der RWTH Aachen University, Germany; {3}MENTOR GmbH & Co. Präzisions-Bauteile KG, Germany*

Tuesday, July 9

P-45

MICROWAVE SENSING USING FLEXIBLE ACOUSTOFLUIDIC DEVICES

*Shahrzad Zahertar, Ran Tao, Richard Fu, Hamdi Torun
Northumbria University, United Kingdom*

P-46

TEXTILE ORGANIC BIOSENSORS FOR ADVANCED WEARABLE HEALTHCARE

*Isacco Gualandi, Marta Tassarolo, Federica Mariani, Erika Scavetta
University of Bologna, Italy*

P-47

OCM-PUF: ORGANIC CURRENT MIRROR PUF WITH ENHANCED RESILIENCE TO DEVICE DEGRADATION

*Zhaoxing Qin{1}, Michihiro Shintani{2}, Kazunori Kuribara{3}, Yasuhiro Ogasahara{3}, Takashi Sato{1}
{1}Kyoto University, Japan; {2}Nara Institute of Science and Technology, Japan; {3}National Institute of Advanced Industrial Science and Technology, Japan*

P-48

GEOMETRY DEPENDENT APPLICATION OF STRETCHABLE PRINTED ANTENNA

*Martina Aurora Costa Angeli{1}, Fatemeh Nikbakhtnasrabadi{2}, Pasquale Vena{1}, Ravinder Dahiya{2}
{1}Politecnico di Milano, Italy; {2}University of Glasgow, United Kingdom*

P-49

CLOTH BASED BIOCOMPATIBLE TEMPERATURE SENSOR

*Libu Manjakkal, Mahesh Soni, Nivasan Yogeswaran, Ravinder Dahiya
University of Glasgow, United Kingdom*

19:00 - 21:00

Banquet Dinner

Location: Marriott Glasgow

500 Argyle St, Glasgow G3 8RR, UK

Conference Dinner on Tuesday, July 9th will be at the Marriott Glasgow. Transportation to the venue will be loaded beginning at 18:00 and depart beginning at 18:15 from the DoubleTree by Hilton Lobby to the Marriott Glasgow. There will be multiple bus trips to and from the hotel to the venue.

Wednesday, July 10

07:30 – 17:30

Registration

Room: Ballroom Foyer

08:30 – 09:30

Keynote Speaker: Corne Rentrop, *Project Leader, Hybrid Printed Electronics Group at the Holst Center, TNO*

Room: Imperial Suite

“Fundamentals and applications of hybrid printed Electronics and how to integrate into flexible, stretchable and three-dimensional products.”

Corne Rentrop

Project Leader, Hybrid Printed Electronics Group at the Holst Center, TNO

09:30 – 10:00

Coffee Break

Room: Cambridge Suite

09:30 – 10:00

Exhibits

Room: Cambridge Suite

10:00 – 11:30

C2L-A: Emerging Materials 2

Room: Imperial Suite

Session Chair: Luigi Occhipinti, *University of Cambridge, UK*

10:00

INVITED TALK: NANOSTRUCTURED FILMS AND POLYMER COMPOSITES OF GRAPHENE AND TWO-DIMENSIONAL MATERIALS: ELECTRICAL AND MECHANICAL PROPERTIES AND APPLICATIONS IN WEARABLE ELECTRONICS

Felice Torrìsi

Imperial College London, United Kingdom

10:30

FLEXIBLE IGZO THIN-FILM TRANSISTORS WITH LIQUID EGAIN GATE CONTACTS

Filippo Spina, Júlio C. Costa, Niko Münzenrieder

University of Sussex, United Kingdom

10:45

AN ANALYSIS OF SCREEN-PRINTED STRETCHABLE CONDUCTIVE TRACKS ON THERMOPLASTIC POLYURETHANE

Jawad Ahmad, Xiaotian Li, Johan Sidén, Henrik Andersson

Mid Sweden University, Sweden

11:00

PRINTABLE SENSORS FOR NITROGEN DIOXIDE AND AMMONIA SENSING AT ROOM TEMPERATURE

Pelumi Oluwasanya, Yarjan Samad, Luigi Occhipinti

University of Cambridge, United Kingdom

Wednesday, July 10

11:15

ENHANCING THE STABILITY OF AGNWS TRANSPARENT CONDUCTING ELECTRODES WITH 2.5Ω/SQ SHEET RESISTANCE BY THE USE OF POST-PROCESSING

Jeff Kettle, Dinesh Kumar

Bangor University, United Kingdom

11:30 – 13:00

C3L-A: Modelling & Simulation 1

Room: Imperial Suite

Session Chair: Ravinder Dahiya, *University of Glasgow, Scotland, UK*

11:30

INVITED TALK: DESIGN OF BENDABLE HIGH-FREQUENCY CIRCUITS BASED ON SHORT-CHANNEL INGAZNO TFTS

Niko Münzenrieder^{3}, Julio Costa^{3}, Luisa Petti^{1}, Giuseppe Cantarella^{1}, Tilo Meister^{2}, Koichi Ishida^{2}, Corrado Carta^{2}, Frank Ellinger^{2}

^{1}Free University of Bozen-Bolzano, Italy; ^{2}TU Dresden, Germany; ^{3}University of Sussex, United Kingdom

12:00

COMPACT MODELING OF ORGANIC TRANSISTORS WITH MULTI-FINGER CONTACTS

Afra Al Ruzaiqi^{2}, Boyko Nikolov^{2}, Lawrence Chen^{1}, Helena Gleskova^{2}

^{1}McGill University, Canada; ^{2}University of Strathclyde, United Kingdom

12:15

MODELLING AND SIMULATION OF A PORTABLE, SIZE-DISCRIMINATING CAPACITIVE PARTICULATE MATTER SENSOR

Pelumi Oluwasanya, Abdullah Alzahrani, Varindra Kumar, Luigi Occhipinti

University of Cambridge, United Kingdom

12:30

ON-OFF CURRENT RATIO IN ORGANIC FERROELECTRIC MEMORY DIODES: THE ROLE OF THE DENSITY OF STATES

Matteo Ghittorelli^{1}, Andrea Adami^{1}, Paolo Romele^{2}, Flavio Giacomozzi^{1}, Leandro Lorenzelli^{1}, Fabrizio Torricelli^{2}

^{1}Bruno Kessler Foundation, Italy; ^{2}University of Brescia, Italy

12:45

RADIO-MECHANICAL MODEL OF EPIDERMAL ANTENNA STRETCHING DURING HUMAN GESTURES

Gabriele Diotallevi^{2}, Carolina Miozzi^{2}, Marco Cirelli^{2}, Pier Paolo Valentini^{2}, Gaetano Marrocco^{1}

^{1}Università degli Studi di Roma Tor Vergata, Italy; ^{2}University of Roma Tor Vergata, Italy

13:00 – 14:00

Lunch

Room: Cambridge Suite

Wednesday, July 10

14:00 – 15:30

C4L-A: Energy Harvesting & Storage Systems 1

Room: Imperial Suite

Session Chair: Luigi Occhipinti, *University of Cambridge, UK*

14:00

INVITED TALK: ENERGY HARVESTING POWER SUPPLIES FOR ELECTRONIC TEXTILES

Stephen Beeby, Russel Torah, John Tudor, Neil Grabham, Sheng Yong, Sasikumar Arumugam, Yi Li, Junjie Shi

University of Southampton, United Kingdom

14:30

SPIN BASED ORGANIC PHOTODIODE

Uzoma Oduah, Olufemi Illori

University of Lagos, Nigeria

14:45

OPTIMIZATION OF HOLE-TRANSPORT LAYER IN SOLUTION-PROCESSED SILVER BISMUTH IODIDE SOLAR CELLS

Yue Yuan, Vincenzo Pecunia

Soochow University, China

15:00

CONTACTLESS STRETCH SENSOR

Aravind Narain Ravichandran, Marc Ramuz, Sylvain Blayac

Centre Microélectronique de Provence Georges Charpak, France

15:15

WATER ACTIVATED PRIMARY TEXTILE BATTERY

Yi Li, Nick Hillier, Sheng Yong, Sasikumar Arumugam, Chris Craig, David Harrowven, Stephen Beeby

University of Southampton, United Kingdom

15:30 – 16:00

Coffee Break

Room: Cambridge Suite

15:30 – 16:00

Exhibits

Room: Cambridge Suite

Wednesday, July 10

16:00 – 17:30

C5L-A: Emerging Applications 2

Room: Imperial Suite

Session Chair: Felice Torrisi, *Univeristy of Cambridge, UK*

16:00

INVITED TALK: ENGINEERING ORGANIC ELECTRONIC MATERIALS FOR THE DEVELOPMENT OF SMART TEXTILES

Esma Ismailova

Ecole Nationale Supérieure des Mines de Saint Etienne, France

16:30

EMBROIDERED RECTANGULAR SPLIT-RING RESONATORS FOR MATERIAL CHARACTERISATION

Shahrzad Zahertar, Linzi Dodd, Hamdi Torun

Northumbria University, United Kingdom

16:45

A 4-CHANNEL PIEZO TRANSDUCER BASED FLEXIBLE HYBRID SENSOR FOR RESPIRATORY MONITORING

Amirhossein Shahshahani, Zeljko Zilic, Sharmistha Bhadra

McGill University, Canada

17:00

LASER-ASSISTED FABRICATION OF FLEXIBLE MICRO-STRUCTURED PRESSURE SENSOR FOR LOW PRESSURE APPLICATIONS

Valliammai Palaniappan, Simin Masihi, Masoud Panahi, Dinesh Maddipatla, Arnesh Bose, Xingzhe Zhang, Binu Narakathu, Bradley Bazuin, Massood Atashbar

Western Michigan University, United States

17:15

STRAIN SENSOR FABRICATION BY MEANS OF LASER CARBONIZATION

Devin Birchfield, Xavier Jackson, Thomas Pasternak, Anthony Hanson, Massood Atashbar

Western Michigan University, United States

17:30 – 17:45

Closing Remarks

Room: Imperial Suite