EMERGE school program:

Time (CET)	Monday 20/3 Presentation of EMERGE project	Tuesday 21/3 TA1	Wednesday 22/3 TA2	Thursday 23/3 TA3	Friday 24/3 TA4
11.00 – 12.00	EMERGE: a pioneer research infrastructure open to all **Prof. Pedro Barquinha (UNINOVA)**	Understanding the process – structure relation in solution processed thin films with the help of phase-field simulation. ***Dr. Olivier Ronsin (FZJ)***	Emerging 2D materials synthesis via wet chemistry ***Dr. Ali Shaygan Nia (TUD)***	Challenges in scaling up printed carbon composites ***Dr Andrzej Peplowski (WUT)***	Ion-based devices and systems: fabrication and verification ***Dr. Peter Andersson Ersman (RISE)***
12.00 – 13.00	Networking Activities (NA): Knowledge and Best Practice Hub (KBest) as an opensource knowledge platform ***Mrs Konstantina Pityanou (HMU)***	Optical simulation of free-form micro-optical elements **Dr. Christian Sommer / DI Wolfgang Nemitz (JOR)**	Solution-combustion synthesis of oxide thin films ***Prof. Rita Branquinho (UNINOVA)***	Printed mechanical sensors on paper and cork **Prof. Luís Pereira (ALMA)**	Raman technology and related issues ***Dr. Barbara Kosednar-Legenstein (MCL)***
13.00 – 14.00	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break
14.00 – 15.00	Transnational Activities (TA): from design and simulation to fabrication and characterization of demonstrators ***Dr. Konstantinos Rogdakis (HMU)***	Modeling of organic electrochemical transistors ***Dr. Hans Kleemann (TUD)***	*Proper methodologies for characterization of inks/pastes of different organic/inorganic materials* ***Dr. Mats Sandberg (RISE)***	Inkjet-printed biosensors based on flexible substrates for biomedical applications ***Dr. Giulio Rosati (ICN2)***	High Throughput Production of Printed Photovoltaics ***Dr Hans-Joachim Egelhaaf) (FZJ)***
15.00 – 16.00	Joint Research Activities (JRA) as enablers of EMERGE improvement and expansion ***Dr. Barbara Stadlober (JOR)***	Modelling TFT degradation through chemical reactions in device simulations ***Dr. Ahmed Nejim (SILVACO)***	Reinventing electronics for a sustainable world ***Mr Julio Costa (Pragmatic)***	Novel pathways for large area electronics using solution processable chemical derivatives of graphene ***Dr C. Mattevi (ICL)***	Industrial roll to roll production of organic indoor solar cells ***Dr. Thomas Österberg (Epishine)***

Short description of the talks

EMERGE: a pioneer research infrastructure open to all	***Prof. Pedro Barquinha***
Emerging Printed Electronics Research Infrastructure (EMERGE) is an EC funded action aiming to establish the first integrated, distributed research infrastructure supporting comprehensive user projects for multi-and-trans-disciplinary research on sustainable flexible large-area printed electronics and photonics (FLAPEP). This introductory presentation will present the overall project, objectives, organization of the network and how users from academia, RTOs, industry and SMEs can get free-of-charge access to world-leading infrastructures to develop short projects related to FLAPEP.	
Networking Activities (NA): Knowledge and Best Practice Hub (KBest) as an opensource knowledge platform	***Mrs Konstantina Pityanou***
EMERGE has created an innovative information and data management platform with embedded artificial intelligence (AI) functionalities for green flexible large area printed electronics and photonics defined as "Knowledge & Best Practice Hub" (KBest) that is accessible from EMERGE users. KBest will establish a platform and metadata standard for data sharing as an open collaborative initiative within the framework of the Research Data Alliance (RDA). KBest in his full development will provide information extracted from data as an automatic analysis and prediction tool, assisting in the learning procedure that can prompt innovation in an unprecedented manner for various innovation-oriented communities enabling the Knowledge acquired by a team to be shared throughout the Open Science platform and finally enabling step by step progressing in a common lexicon.	
Transnational Activities (TA): from design and simulation to fabrication and characterization of demonstrators	***Dr Konstantinos Rogdakis***
EMERGE users have access in an integrated manner, to four available typologies of TA that are based on the integration of experimental and theoretical facilities. *TA1- Access to design, modelling and simulation facilities* addresses projects oriented on high-resolution multiscale process simulations, as well as machine learning based on artificial intelligence (AI) approaches giving insight and guidelines for novel material growth, functional design, and fabrication. *TA2- Access to materials synthesis and characterization facilities* is devoted to faster, cheaper and more sustainable (e.g., bio-based) ink & pastes formulation with improved quality control dedicated to specific applications. *TA3- Access to prototypes fabrication facilities* focuses on highly efficient production of sophisticated and complex FLAPEP systems with high conformability and	

integrability dedicated to specific application needs allowing upscaling and technology transfer processes towards industrial production. *TA4-Access to demonstrators' test, validation and characterization* aims to establish performance and stability tests under industrial protocols in simulated and real conditions for various types of devices using a wide variety of available characterization methods aiming at specifying universal metrology protocols.	
Joint Research Activities (JRA) as enablers of EMERGE improvement and expansion	***Dr B. Stadlober***
The Emerge partners are developing some novel services by cooperating within the framework of three Joint Research Activities (JRA). JRA1 is about Research on hybrid printing setups with quantitative in-line measurement methods for high precision fabrication of bio-nano systems and it deals with artificial neuronal networks fabricated by screen-printed OECT circuits, stand-alone wearable biosensors and R2R-based molecular imprinting for antimicrobial and/or cell-binding foil surfaces. JRA2 Research on high throughput novel inks/pastes synthesis is devoted to the joint development of novel ink formulations and processing techniques for printed electronics. Finally, JRA3 Research on functional 3D printing for multifunctional smart objects with interactive free-form surfaces focusses on realising a smart multi-functional 3D printed object with some components embedded and others integrated in a direct-to-shape approach on the curved surface with a 5-axis combined inkjet and Aerosoljet printing machine.	
Understanding the process – structure relation in solution processed thin films with the help of phase-field simulations	***Dr. Olivier Ronsin***
The processing conditions strongly impact the morphology of solution-processed organic and inorganic thin films, and thus their properties. In this talk, we will show how the process-structure relationship can be modelled using phase-field simulations in order to predict the dry film structure, understand the morphology formation pathways and propose new design rules for the processing conditions. Comparisons of theoretical results with experimental measurements will be shown with the example of both organic and perovskite solar cells.	
Optical simulation of free-form micro-optical elements	***Dr. Christian Sommer / DI Wolfgang Nemitz***
Optical microstructures are present in many application areas (lighting, display, automotive, communication, etc.) of daily life and enable new design approaches to realize the desired optical functions in the smallest space. To achieve this, appropriate optical design and simulation tools are needed to support the development process, especially for lighting applications, but also in numerous other application areas such as automotive lighting, photovoltaics and communication technologies. In this talk, an insight into the design and optical simulation of (free-form) micro-optical elements (FF-MOEs) will be given by means of specific examples.	
Modeling of organic electrochemical transistors	***Dr. Hans Kleemann***
Organic electrochemical transistors (OECTs) appeal as highly attractive candidates for a new generation of organic neuromorphic devices as well as biosensors. However, in order to progress towards circuit integration to implement hardware-based AI, precise quantitative models of such devices are needed. In this lecture, I will review established OECTs models starting the Bernards model and its extensions to describe the static	

and dynamic response. In addition, as such models fail to explain very important features of OECTs, I will introduce recently developed thermodynamic models.	
Modelling TFT degradation through chemical reactions in device simulations	***Dr. Ahmed Nejim***
TFT stability is an important technology adoption quality factor. Predicting device degradation is essential in developing mitigation strategies and designing deployment scenarios. If device design would ever add value, it would have to grapple with degradation prediction.	
Emerging 2D materials synthesis via wet chemistry	***Dr. Ali Shaygan Nia***
2D materials are important building blocks for the next generation of electronic and energy devices due to their remarkable chemical and physical characteristics. To this end, large-scale production of 2D materials with high purity and specific functionalities represents a key to advancing fundamental studies and industrial applications. Within this lecture, we are introducing the scalable wet chemistry methodologies to synthesized 2D materials. In particular, we introduce the electrochemical exfoliation (Adv. Mater. 2020, 32, 1907857) of layered materials that offers high yield, great efficiency, low cost, simple instrumentation, and excellent up-scalability. Remarkably, playing with electrochemical parameters enables functionalization and tunable material properties and increases the material diversities from graphene to a broad spectrum of 2D semiconductors (Adv. Mater. 2020, 32, 1907244; Small 2019, 15, 1901265; Angew. Chem. Int. Ed. 2018, 57, 4677-4681; Angew. Chem. Int. Ed. 2018, 57, 15491-15495). High solution processability of 2D materials via electrochemistry also offers hybridization/functionalization of 2D materials and the development of functionalized inks for printing technologies.	
Solution-combustion synthesis of oxide thin films	***Prof. Rita Branquinho***
The possibility to print materials has drawn tremendous interest in solution processible materials for electronic applications, however high processing temperatures can be an obstacle. Solution combustion synthesis has been applied to produce semiconductor and conductor and dielectric oxide thin films. All of which are required for numerous electronic devices and applications such as fully oxide based TFTs. The properties of produced thin films are highly dependent on the precursor solution characteristics; hence the influence of several processing parameters; organic fuel, solvent and annealing temperature must be considered. Solution combustion synthesis is becoming one of the most promising methods for low temperature flexible electronics.	
Proper methodologies for characterization of inks/pastes of different organic/inorganic materials	***Dr. Mats Sandberg***
Inks/pastes development and characterization methodologies are crucial complementary processes to all printing technologies. Herein, important parameters for both organic and inorganic materials, ink/paste compositions and their functionalities are discussed in relation to their printability and final performances. Methods by which to manufacture, scale-up and characterize inks and paste are presented.	
Reinventing electronics for a sustainable world	***Dr Julio Costa***
Key global challenges we face require innovative approaches that can be deployed ubiquitously. As a world leader in ultra-low-cost Flexible Integrated Circuits (FlexICs) Pragmatic Semiconductor's technology and FlexIC Foundry™ offering enable innovative designers to create ubiquitous low-cost smart systems	
Challenges in scaling up printed carbon composites	***Dr Andrzej Peplowski***

We will present our design process and onset of upscaling in the R&D focused on printed pressure sensors for orthopedic rehabilitation. It'll be a case study of some of key stages we had to go through to be ready to transit to a fully industrial-scale fabrication. We'll also showcase a more advanced project of printed heaters that are now in a full mass-production.	
Printed mechanical sensors on paper and cork	**Prof Luis Pereira**
Interactive surfaces can impact different application fields such as domotics or smart retail, considering the possibility of object and individual recognition. Moreover, these surfaces can also be used to convert mechanical stimulus into electrical signals. With the aim of making these surfaces an ubiquitous, affordable and sustainable technology, we are implementing them on natural materials substrates. In this presentation ALMA will give some insights on the materials and processes to produce pressure sensing and energy harvesting on paper and cork and demonstrate some use cases such as smart shelves and input devices that can be combined with conventional electronic devices.	
Inkjet-printed biosensors based on flexible substrates for biomedical applications	***Dr. Giulio Rosati***
Inkjet printing drop-on-demand technology has many advantages for the fabrication of bioelectronics platforms and nanobiosensors for use in many fields, and in particular for biomedical applications. In this lecture, we will present the basic concepts of biosensing and nanobiosensing devices, their most common fabrication methods and the respective pros&cons, and the potential of inkjet printing for the development of low-cost, user-friendly, sensitive and point of care devices for biomedical applications.	
Novel pathways for large area electronics using solution processable chemical derivatives of graphene	**Dr Cecilia Mattevi**
Low cost high quality graphene production and its scalable and reliable deposition onto large areas remain challenging. Solubilization of graphene could potentially be a valuable option that allows large-scale production and processing. In this regard, we focused our attention on oxygen-functionalized graphene that is water-soluble. Here, I will present our work on enabling novel pathways for large area electronics using solution processable chemical derivatives of graphene. Correlation between electrical, structural and chemical properties of chemically derived graphene thin films along with novel tuneable opto-electronic properties, such as photoluminescence and giant IR absorption, will be discussed. Further, understanding of the atomic structure evolution of chemical derived graphene upon thermal treatment will be reviewed as an invaluable tool to design novel functionalized graphene and novel graphene interfaces. The last part of my talk will demonstrate how new processing method and capabilities can be applied in designing novel graphene interfaces, which include metals and organic molecules, for practical devices.	
Ion-based devices and systems: fabrication and verification	***Dr. Peter Andersson Ersman***
Ion-based devices such as transistors, displays and sensors etc. are utilized in various functional printed organic electronic systems. Here we describe the functionalities of ion-based devices and systems and provide insights into common uses and high-performing systems to date. Moreover, we will discuss typical fabrication and verification methods of ion-based systems.	
Raman technology and related issues	***Dr. Barbara Kosednar-Legenstein***

Raman spectroscopy is fast and uncomplicated optical method for material characterization. Besides the investigation of the chemical composition of materials or the determination of crystallinity, it is also possible to detect other aspects like phase transitions or residual stresses. Moreover, samples can be analysed in situ under different conditions over time (e.g. changes in temperature, application of an electrical field or under mechanical load). The achieved results can thus provide information, for example on the aging behaviour of a wide variety of materials. In this presentation, the basics of Raman spectroscopy and its application in the field of flexible electronics will be shown.	
High Throughput Production of Printed Photovoltaics	**Dr Hans Hans-Joachim Egelhaaf**
The talk gives an introduction to roll-to-roll printing of photovoltaic modules. Material selection, module layout, processing techniques, quality control and module testing will be discussed. We will also demonstrate how R2R printing equipment can be beneficially employed for accelerating process development. Finally, examples of present and future applications of printed photovoltaics will be presented.	
Industrial roll to roll production of organic indoor solar cells	***Dr. Thomas Österberg***
Introduction to indoor photovoltaics, considerations for high throughput indoor solar cell volume production and how this couples to different market applications	