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Workshop on Nano-Enabled Printed Electronics

Vanguard Pilot “New Nano-Enabled Products”

Wednesday, April 18th 2018, KIT North Campus, Institute of Nanotechnology Bldg. 640

Program

09:00	Meet & Greet
09:30	Welcome Notes
09:45	Printed Electronics – buzz word or real enabler *Heike Pfistner (BASF)*
10:15	Functional printing – Printed electronics and sensor integration *Ingo Wirth (Fraunhofer IFAM)*
10:45	Coffee Break and Discussion
11:15	Short Presentations (SMEs, Pilot Lines, RTOs) DoMicro, EPPN, InnovationLab, KIT, myPrint, TicTag, DITF Denkendorf, Elmeric
12:30	Lunch
13:30	Hybrid electronics integration by inkjet technology *Peter Visser (InnoVisser)*
13:50	Functional printing at Hahn-Schickard *Jürgen Keck (Hahn-Schickard-Gesellschaft)*
14:10	Shapetronics *Philippe Guaino (CRM Group)*
14:30	Coffee Break and Discussion
15:00	The SILENSE project: ultrasound transducer matrices based on roll-to-roll manufacturing *Blas Puerto Valcarce (Prodintec)*
15:20	Wearable printed and flexible biosensors *Marta Tessarolo (University of Bologna)*
15:40	Durable and ultra-affordable sensors for smart surfaces *Ivica Kolaric (Fraunhofer IPA)*
16:00	Closing Remarks and Adjourn

Supported by: Baden-Württemberg Ministry of Economic Affairs, Labour and Housing; KIT Karlsruhe Institute of Technology

Talks

Printed Electronics – from technical invention to real enabler?

Heike Pfistner (BASF)

The presentation gives a snapshot on BASF's view on the status of the Printed Electronics industry, the challenges this industry faces and BASF's approach to commercialization. Besides this, a brief overview of other networks directed to enable manufacturing of printed electronics will be added.

Functional Printing – Printed Electronics and Sensor Integration

Ingo Wirth (Fraunhofer IFAM)

Printed electronics allow special properties and functionalities to be readily realized. For the realization of sensor integration, various technologies such as 3D-printing, inkjet printing, aerosol printing as well as sputtering, compounding, and extruding techniques are applied. All classes of materials, including polymers, ceramics and metals, can be processed using printing or jet methods on films, flat products or components with optimum use of resources. A wide range of components for electronic applications are manufactured via printed electronics. Currently the main focus of development work is on different types of sensors, but also on storage elements, display systems, batteries, and intelligent textiles. Various additive processes are used to meet customer requirements regarding functionality, material, substrate, structure size, and batch size. Here, the material can either be adapted to a specific printing process or to a special substrate. A precondition, besides having the desired electronic functionality, is that the materials are able to flow, namely are a solution, dispersion or suspension.

Hybrid electronics integration by inkjet technology

Peter Visser (InnoVisser)

Hybrid electronics integration by inkjet technology. DoMicro BV has progressed in advanced packaging and integration of conventional electronics in flexible foils structures. Printing multi-layers, passive components and interconnection of thinned silicon dies is enabled by revolutionary developments in nano-printing and specific inkjet technology. Several examples will be discussed including a functional flexible micro sensor application.

Digital functional printing at Hahn-Schickard

Jürgen Keck (Hahn-Schickard)

The scope of digital functional printing at Hahn-Schickard Stuttgart will be presented. This includes inkjet and aerosol jet printed sensors based on nano metal inks. Possibilities to connect printed patterns with conventional electronics are also discussed as well as pre- and post-treatment of substrates and printed inks.

Shapetronics

Philippe Guaino (CRM Group)

Printed electronic in combination with advanced material development pursues mega trends with new markets and businesses for flexible, stretchable and large area electronic. More recently, beyond 2D, printing electronic on 3D object is also growing. This technology become an integrate part of the Internet of Things (IoT), by making smart system displays, sensors and active functional surfaces.

Most of these printed devices are currently integrated on plastic foils, papers and textiles. Nevertheless, metallic substrates appear to be also a promising alternative for several raisons. First, metal can overcome important arising technological difficulties due to the shortcomings durability, moisture barrier properties (particularly for organic material) and heat dissipation. Moreover, metal will allow very original smart applications in Building, Appliance and Automotive. In addition, it offers a very nice opportunity to address the 3 D world combining electronic functions and makes possible a future generation of printed and low cost electronic devices in the metallurgy world.

The SILENSE project: ultrasound transducer matrices based on roll-to-roll manufacturing.

Blas Puerto Valcarce (Prodintec)

The SILENSE project focuses on the development of smart acoustic and ultrasound technologies for Human-Machine and Machine-Machine Interfaces. Compared to other solutions, acoustic technologies facilitate much simpler, smaller, cheaper and easier to integrate transducers. They can enable interfaces, which are more intuitive and inclusive and that can offer improved hygiene, enhanced safety by touchless control and enhanced security by gestural authentication. The technology will be demonstrated in several applications in mobile, wearable, smart home, automotive and under-water domains.

The project covers design, development and manufacturing of beyond-the-state of the art micro-acoustic transducers, and develops novel package and assembly technologies, together with the supporting electronics and software. PRODINTEC is developing an assembly technology based on roll-to-roll manufacturing processes over flexible substrates. The process flow includes substrate perforation for acoustic ports, ink-jet printing and sintering of conductive tracks, attachment of the transducer components to the printed circuit, connection of terminals and encapsulation. SILENSE is run by a consortium of 31 highly specialized organizations from industry and academia and is coordinated by NXP Belgium. It is co-financed by the European Union's HORIZON 2020 program.

Flexible, ultra-low voltage, fully printed radiation detectors based on organic semiconductors

Marta Tessarolo, Beatrice Fraboni (University of Bologna, Department of Physics and Astronomy)

A new generation of ionizing radiation sensors based on organic materials is attracting a large attention exploiting appealing features of such as ease of processing, low power supply and mechanical flexibility. Moreover, the equivalence of the typical density of organic molecules to that of human tissue makes them very suitable for medical X-ray direct dosimetry.

In the field of ionizing radiation detection, organic materials have been mostly employed so far in indirect radiation detection systems, either as scintillating material or as (organic) photodetectors.

Our approach is based on the use of organic semiconductors as the active material for the direct detection of ionizing radiation, implementing real-time and room temperature operating sensors. In the last years, a few works reported the proof-of-principle for direct X-ray detection based either on organic semiconducting single crystals [1] or on polymer thin-films blended either with π-conjugated small molecules, inorganic high-Z nanocomponents [2] to enhance the sensitivity to X-rays improving the charge carriers mobility and the stopping power of the material.

We fabricated direct, thin detectors based on micro-crystalline thin films of TIPS-pentacene deposited by inkjet printing onto flexible substrates and we assessed their high X-ray sensitivity (up to several hundreds of nC/Gy at ultra-low bias of 0.2 V). We investigated the direct X-ray photo-conversion process in order to interpret the detection mechanism and we developed a kinetic model that gives an important insight into the physical process that leads to highly sensitive response to ionizing radiation by such low-Z organic materials.

Finally, we assessed the possibility to use the detector under mechanical strain and gave the first demonstration of a 2×2 pixelated matrix organic detector [3].

These results open the way for novel flexible, large area and low voltage ionizing radiation detection systems, capable of providing quantitative and real time information on the dose rate and on the spatial distribution of impinging radiation.

References

[1] Fraboni, B. et al. Adv. Mater. 24, 2289–2293 (2012); Basirico, L. et al. IEEE Trans. Nucl. Sci. 62, 1791–1797 (2015); Ciavatti, A. et al. Adv. Mater. 27, 7213–7220 (2015).

[2] Intaniwet, A et al. Nanotechnology 23, 235502 (2012); Mills, C. A. et al. J. Phys. Appl. Phys. 46, 275102 (2013).

[3] Basirico' L, et al. Nature Comm. 7 13063 (2016)

Nano enhanced Ultra-durable large Area Sensors for automotive applications

Ivica Kolaric (Fraunhofer IPA)

German transportation industry is one of the strongest industries in the world. Especially the segment of automotive production is worldwide appreciated for its engineering and production capabilities. Whilst many European OEMs are suffering on declining sales, German premium brands still increase their production capacities worldwide. The German automotive industry has been the national driver of innovation for decades and the largest industry segment. To maintain this dominate position Germany OEMs need to face many challenges: the explosion of varieties and the resulting complexity of the production process, the shift of the key sales markets, the rising demand for electro vehicles and connectivity. These challenges will lead to a huge demand on new and better materials, e.g. for more efficient and precise electronics, energy storages systems with higher energy density as well as lighter and stiffer materials for car bodies and new human machine interface technologies. Carbon Nanotubes can play an important role to face these challenges. They can be used in applications such as energy storage, coatings and reinforced plastics. Within this talk, the application as large area sensor will be introduced and discussed. CNT based sensors have been integrated into car body and showing a good performance as durable sensor supporting the developments for connected cars

SME/Pilot Session

Fabricating smart hybrid integrated stacked multiple substrate printed systems

Liane Koker (KIT, IAI)

The "System integration" work group is part of the Institute for Automation and Applied Informatics (IAI) at KIT. It researches and develops methods and technologies for the integration of complex systems used in nano- and micro-technology. The group aims to achieve a comprehensive development approach starting from system design, process and equipment development, up to optical inspection. Core competencies include methodical system design, dispensing techniques for small quantities, techniques for printing of functional structures, handling processes and automation technology.

EPPN Digital marketplace for pilot lines

Paula Galvao (International Iberian Nanotechnology Laboratory)

INL – International Iberian Nanotechnology Laboratory - INL is a nanotechnology development center with headquarters in Braga, Portugal. As the first and only international intergovernmental organization dedicated to nanotechnology, INL provides in-house expertise combined with streamlined access to a worldwide network of partners, investors, and potential markets.
We excel in the development of customized solutions that directly address industry-specific needs via an integrated knowledge approach.

Hybrid electronics integration by inkjet technology

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Digitally Printed Flexible Organic Photodiodes

Gerardo Hernandez-Sosa (KIT – LTI)

Nanotechnology, visual ergonomics, materials science and system design – these are a few examples from the wide spectrum of light technology research projects and services at our institute. In Printed Electronics, we focus in the development of processes and fabrication of devices for light emission, detection and management.

Fully Printed Force Sensors by InnovationLab GmbH - Overview, Function Principle & Showcases

Thomas Rohland (InnovationLab GmbH)

InnovationLab is an application-oriented research and knowledge transfer platform of business and science in the Rhine-Neckar metropolitan region. Organized in a public private partnership, all of iL's partners share the common goal of driving innovation faster into markets.

How to print a sensor?

Sylwia Sekula-Neuner (myPrint)

µyPrint is a spin-off project born in the Dip-Pen Nanolithography lab at the Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT). We have developed a novel modular desktop printer for fast surface and device functionalization with a variety of inks. This printer can be applied to spectra of disciplines ranging from nanobiomedical applications to material research and microelectronics.

Functional printing – We link electrical engineering to print technologies

Werner Fink (Elmeric)

Elmeric entwickelt und produziert verschiedenste Produkte aus dem Bereich „gedruckte Elektronik" über das Druckverfahren Siebdruck. Gedruckte Batterien, die einen an eine RFID-Antenne gekoppelten Chip mit Kapazität versorgen oder ein Touch-Slider, der seine Funktionalität durch gedruckte leitfähige Polymere erhält, sind u.A. Entwicklungen von Elmeric. Eine weitere hier vorgestellte Innovation ist das Löten auf gedruckten Silberleitbahnen, was bis vor Kurzem noch unmöglich war.

Eco-friendly Fabrication of Organic Solar Cells from Nanoparticle Inks

Felix Manger (KIT - LTI)

Organic photovoltaics feature unique advantages compared to other technologies such as semi-transparency and mechanical flexibility. This enables a currently untapped potential for the integration of photovoltaics in a wide range of applications. Since organic photovoltaics can be all-solution-processed, the mass production via printing processes will allow cheap and fast production.
One remaining difficulty for up scaling the production of organic photovoltaics is the usage of toxic solvents. Therefore, we have proposed a novel approach of processing the organic materials as surfactant-free nanoparticle dispersion by precipitating them in harmless fluids like alcohols or even water. Through the use of advanced measurement techniques, we have found that on the one hand the dispersions consist of nanoparticles with a favorable morphology and one the other hand the layers made from the dispersions are sufficiently smooth, leading to solar cells with a comparable efficiency to solution-processed solar cells.
Since we could show that the nanoparticle ink is suitable for up scaling by evaluating different processing methods and taking into account the long-term stability, the nanoparticle solar ink is suitable as a ready-to-use product for roll-to-roll processing by printing companies.

Poster contributions

Development, printing and post processing of long-term stable inorganic inks for printed electronics

Julia Gebauer, Viktor Mackert (University of Duisburg-Essen)

There is a growing interest in science and industry for printed electronics. Printed electronics allow the production of larger quantities of electronic components at low costs. Even though organic semiconductors are already widely used for printed components, partially inorganic materials are advantageous due to their high durability and their superior device performance. On the other hand, a common drawback of inorganic semiconductors is the high processing temperature, which strongly limits the use of low-cost or flexible substrates. In order to overcome this problem we apply resonant UV-laser sintering as thermal post treatment method. In this work we present the formulation, printing and post processing of newly developed inks based on ethylene glycol as dispersion media. Different metal oxides (ZnO, TiO2, CuO, SnO2 and In2O3) were stabilized and the colloidal stability was evaluated by a combination of DLVO simulations and DLS measurements. The inks show narrow size distributions, excellent long-term stability and adjustable rheological properties that make them ideally suited for printed electronics. The newly developed ink formulations are stabilized using the same dispersion media. Therefore, they allow mixing of different nanoparticles inside the same ink. We show that this enables completely new production routes to designing complex oxide materials like Zn2SnO4 (ZTO) through reactive laser sintering. Resonant UV-laser sintering of metal oxide structures is advantageous, due to short processing time, efficient energy deposition and localized heat load, which makes it ideal for printing on flexible substrates.

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