

Workshop and Summer School „Printed Electronics and Foil Assembly“

07. - 10. June 2011, at Fraunhofer EMFT in Munich

Workshop Program on Tuesday, 07. June 2011

The progress in photoacoustic measurements of printed conductive layers - Nikola Perinka, University of Pardubice

For the reliability of the printed functional devices, the quality of the printed layers must be observed and evaluated. Currently, for these purposes different methods can be used. However some of the methods may have certain drawbacks and therefore new methods are still being searched and developed. For instance, one of important parameters is the resulting thickness of printed functional layer. The layer thickness can be determined either by mechanical (or optical) profilometers. As another approach, the spectroscopic methods can be named, e.g. UV-VIS or the photoacoustics. The main advantage of the spectroscopic methods consists in the fact that they are not affected by the unevenness of the substrate; and they are usually non-destructive. After receiving some promising results based on photoacoustic measurements of spiral coated functional layers, further measurements have been done to prove the capability of this method for the determination of layer thickness with the screen printed transparent conductive polymer layers on transparent and non-transparent substrate. Currently, some new interesting results have been obtained by the photoacoustic measurement of silver based conductive composite printed layers as well.

Inkjet Printed Functionalities - fundamentals and applications - Jens Hammerschmidt, Technische Universität Chemnitz

In the last two decades inkjet printing has been applied increasingly as a technology for the deposition of functional materials. The talk gives an overview about several aspects of this promising development which are in the scope of research at the Chemnitz University of Technology. The presented approaches comprise basic studies on the formation of patterns in the inkjet printing process as well as the manufacture of functional applications, such as electronic devices and so called microsieves.

COSMIC : the challenges to meet the requirements of Full Printed organic CMOS Circuits - CEA-Liten

Not yet available

Opportunities and challenges on creating an RFID Silent Tag using printed electronics

- Humberto Moran, Friendly Technologies

Many experts have highlighted the possibility of producing RFID tags using printed electronics. The possibility of individual tailoring at low cost makes of printed electronics an ideal technique for the manufacturing of such devices. Such tailoring would allow tagging heterogeneous objects with flexible RFID tags, simplify the circuitry necessary to assign tag identities, and create ad-hoc interfaces with other applications, for example flexible displays. The opportunities are significantly augmented by a special type of RFID tag, the so-called Silent Tag. Such devices differ from conventional RFID in which they only reply when presented with their unique identity, which makes them ideal for security applications and to protect consumer privacy when used in fast moving consumer goods. Compared to conventional RFID tags, Silent Tags require simpler circuitry and are therefore closer to the possibilities of printed electronics. However, there are a number of challenges facing the production of conventional or silent RFID tags with printed electronics, for example the mobility supporting the necessary transmission or reception frequency. This presentation details such challenges and the opportunities behind them, especially the commercial opportunities and applications of Silent Tags; and provides insight on the state-of-the-art in the printing of RFID devices and what COSMIC is doing to advance it.

Roll-to-roll based fabrication technologies for organic and large area electronics

- Arto Maaninen, VTT Technical Research Centre of Finland

VTT Technical Research Centre of Finland is a globally networked multitechnological contract research organisation, which provides high-end technology solutions and innovation services. In the field of printed electronics and intelligence, VTT has been investing strongly in technological development and related infrastructure since the late 1990s. As a result of this, VTT possesses extensive knowledge and experience to the materials, processes, and the components for printed intelligence. This talk focuses on continuous roll-to-roll (R2R) fabrication techniques for large-area electronics. The presentation covers not only transistor fabrication, which is the aim of the POLARIC project, but gives an overview to the general challenges and possibilities of the R2R based manufacturing. Key aspects of R2R processing, such as available process methods and how to combine them, pattern registration, and feature resolution are discussed.

Organic electronic human-machine interfaces: examples and perspectives

- Adrian von Mühlennen, Centre Suisse d'Electronique et de Microtechnique

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POLARIC - Printable, Organic and Large-Area Realisation of Integrated Circuits

- Kimmo Solehmainen, VTT Technical Research Centre of Finland

To date the use of organic thin film transistors and circuits in industrial products has been limited. The main obstacle for substantial market penetration of such organic electronic components has been the inability to achieve sufficient device performance using high-volume production methods such as printing. This has delayed the commercially viable implementation of organic transistors in complex electronic circuits and system development. In response to this, European Union funded POLARIC project aims to revolutionise the way printed electronic circuits are made and simultaneously, take a major step forward in the device performance. As a result, high-performance organic electronic circuits will be realised using large-area fabrication methods. The high performance of the organic circuits referred to here means high speed (kHz-MHz range), low operating voltage (below 5 V), low power consumption, and low parasitic capacitance. The organic transistor fabrication development will be focused to enable a high resolution step, which will be compatible with roll-to-roll printing. This high resolution step will enable smaller transistor channel length (below 1 μm) and thereby an increase in the performance of the device. Also complementary transistor technology will be developed, enabled by availability of both n- and p-type organic semiconducting materials. The high performance organic transistors will be tested in basic electronic building blocks such as inverters and ring oscillators. After this, more complex circuits will be used in the technology demonstrators. The main demonstrators will be printed active matrix liquid crystal display and radio-frequency identification tag. In addition to showing that sufficient performance can be reached without sacrificing the mass fabrication approach, solutions for the fabrication of roll-to-roll tools in order to make serial replication viable will be provided. Finally, the circuit design, modelling, and characterisation of organic electronics will be developed to offer a toolbox similar to that of silicon-based microelectronics. The presentation covers the general targets and activities the project.

Printing and imprinting of organic electronic devices for multi-component sensors and logic circuits

- Herbert Gold, JOANNEUM Research Forschungsgesellschaft mbH

The speed of circuits in large area electronics depends on the channel-length of OTFTs as their basic components. Nano-imprint lithography offers sufficient resolution to decrease the channel length below a micro meter enabling cut-off frequencies in the MHz regime with today's state-of-the-art mobilities of organic semiconductors. Residual free imprinting and self-alignment concepts are employed in different imprinting techniques to fabricate sub-micron OTFTs. Nano-imprinting is suitable for roll-to-roll manufacturing as an industrial mass-production processes.

An all-printed active matrix sensor based on a pyro- & piezoelectric polymer which is sensitive to infrared laser, pressure and finger movement is presented. Three different components are printed with only five different materials and integrated on a single substrate.

Patterning with μ -CP - Martin König, Fraunhofer EMFT

In the emerging field of large area electronics polymer foils play a key role for large and flexible electronic, illumination and display systems. In contrast to silicon, however, polymer substrates, and in particular foils are hard to structure on a scale below 10 μ m due to surface roughness and surface defects caused by industrial manufacturing process.

The purpose of the work which will be shown in the presentation are the results of structuring metallized polymer foils with microcontactprinting technology.

Title not yet available - Alasdair Campbell, Imperial College London

Chemistry and processing related aspects on the charge injection from source/drain contacts in organic thin film transistors

- Robert Müller, IMEC

High frequency organic circuits, such as for example organic radio-frequency identification tags, require organic thin film transistors displaying good mobility at short channel length. Although an increasing number of small molecule and polymer semiconductors with high hole or electron saturation mobilities have been developed during the past years, corresponding short channel transistors still suffer often of the contact resistances.

In this part of the workshop the influence of chemistry and processing related aspects on the charge injection from the source/drain contacts into the semiconductor will be discussed. Based on these considerations, we furthermore present short-channel ($L = 5 \mu\text{m}$) bottom-gate bottom-contact pentacene transistors achieving hole saturation mobilities of 0.4 $\text{cm}^2/(\text{V}\cdot\text{s})$ with a gold free source/drain metallization costing twenty times less than a traditional 30 nm thin gold layer.

Electrical Stress on Film Resistive Structures on Flexible Substrates - Detlef Bonfert, Fraunhofer EMFT

One of the most important issues of resistors properties is the value stability under different electrical and non electrical influences. Mechanical and/or thermal stress together with the electrical one represent the main factors that have a major contribution in resistor value stability. With highly isolating and/or flexible substrates the devices become also susceptible to electrical stress, like for example Electro Static Discharge (ESD). In order to investigate the behavior at high current densities, a pulsed measurement technique was applied to the film resistive structures on flexible substrates. The analytical test technique of Transmission Line Pulsers (TLP) allows, on the basis of square pulses, the in-situ monitoring of the voltages and currents at the Device Under Test (DUT) during pulsing and helps to gain fundamental insights into the electrical behavior at higher current densities. In this work the analysis is made on thickfilm resistors on flexible substrates, with single and multiple pulsing, showing the behaviour before, during and after pulsing.

Workshop Program on Wednesday, 08. June 2011

Process Development - From Lab to Production Scale - Roger Pretot, BASF Schweiz AG

This presentation introduces the concept of process development in contrast to research, the shift in focus, methods and way of thinking. Chemical research invents new molecular structures and publishes methods to synthesise these molecules. With a published method, in theory, everybody can repeat the synthesis. But most chemists experience themselves the difficulty to reproduce a synthesis achieving exactly the same yield or impurity profile based on these methods.

Based on a synthesis procedure from research, process development tries to improve reproducibility keeping in mind any restriction set by production equipment and safety. For production it is absolutely necessary to have reproducible and stable processes to obtain products within defined specifications.

INTERFLEX: Interconnection Technologies for foil-based Flexible Systems - Metin Koyuncu, Robert Bosch GmbH

The main objective of Interflex is the development of reliable assembly and interconnection technologies for foil based electronic systems. The research and development focus is on the development of interconnection technologies between flexible components and flexible foils (2D-Integration) as well as between functional foils (3D-Integration). The former aims to obtain functional foils, whereas the latter aims three dimensional functional foil integration to achieve multi-foil based systems, i.e. system-in-foil. A flexible energy autonomous system-in-foil is designed as a technology demonstrator that monitors the air quality at indoor conditions and is capable of wireless communication of the measured data. The demonstrator consists of three subsystems: energy, sensing and communication. The subsystems consist of a spectrum of components ranging from photovoltaic cells and thin film batteries (TFB) to sensors and ICs, spanning from sizes of 50x60mm² to 0,7x0,7mm². The diversity in the geometry, structure and thermal tolerance of the components requires innovative heterogeneous integration techniques and process flows. A common level of understanding and a close interaction at a very early stage are also essential between the system designers, component suppliers, and process owners. Standardisation is an important aspect where joint proactive effort within the European research and development landscape is aimed in international standardisation activities. Keeping the industrialisation potential in mind, a modular approach is taken to define a 2D- and 3D-Integration process flow for the realisation of a system-in-foil.

Thin Film Batteries and Electrochromatic on Flexible Foils - Messaoud Bedjaoui, CEA-Liten

SMART-EC aims at the development of self powered (energy harvesting and storage) EC device integrating EC thin film transistor component on a flexible substrate for energy saving, comfort and security in automotive, e-cards and smart packaging sectors.

The objective is to overcome the current limitations related to low switching time and manufacturing costs; the switching time can be reduced by introducing nanostructured EC materials, innovative EC transistors and high ionic conductive solid electrolytes.

The role of CEA is to develop and assess the performances of TF battery and EC compatible with system requirements: electrical performance, compatibility PV technologies, compatibility with on flexible foil heterogeneous integration techniques. CEA will integrate EC layers with TF battery using all inorganic solid-state architecture. The multifunctional nanostructured V₂O₅ will be used as anodic EC material and cathodic TF battery. The TF battery anodic material will be chosen depending on the requested voltage of the developed EC device. The transparent highly conductive polymeric or inorganic electrolyte will be used for the EC device and TF battery.

Interflex targets the development and standardisation of interconnects within flexible foil systems: On-foil connections of different components on a single substrate foil and interconnection of several functional foils into a foil system. The homogeneous integration of electrical components on foils, heterogeneous Si IC-to-foil and foil-to-foil integration will be developed.

The interconnection technologies will be applied in the realisation of a flexible energy-autonomous system for environmental sensing with radio frequency communication capabilities. A combination of flexible amorphous silicon, photovoltaics and thin film foil battery provides the energy for driving sensors (temperature, dew point, humidity, CO₂ concentration).

The all-solid state battery (inorganic anode, cathode and electrolyte) technology performed by CEA for the Interflex project has a higher potential of being compatible with a multi-foil technology. The TFB technology will be adapted to the selected flexible foil substrate in line with voltage and power specification. The compatibility of the active layers and the encapsulation with the temperature, chemistry, pressure, bendability constraints of the 2D/3D foil assembly processes will be assessed. The outcome will be a TFB technology compliant to 2D- and 3D-Integration process requirements.

Heterointegration of foil components and printed circuit foils for flexible electronics

- Erwin Yacoub, Fraunhofer EMFT

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Printed multifunctional heterogeneous devices for efficient and sustainable mobility

- Vito Lambertini, Centro Ricerche Fiat S.C.p.A.

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Inkjet Printing of Inorganic Materials for Electrochromatic Window and Dye-sensitized Solar Cell Applications

- Pawel Jerzy Wojcik, Universidade Nova de Lisboa

In this work we present a new approach for the fabrication of an inorganic electrochromic window and dye-sensitized solar cell by inkjet printing technique, which is ideal for cost efficient mass production.

This technology has provided flexibilities in designing electrochromic devices with different degrees of optical modulation and switching time (film microstructure and composition) and hence widens their application in advanced technologies. In order to investigate the influence of the α -WO₃/TiO₂/WO_x film composition and microstructure on electrochromic performance we performed complex studies using Design of Experiment. Right selection of WO₃ precursor, WO_x/TiO₂ nanocrystals and process parameters allows layers creation also on low cost, heat sensitive substrates, such as polymers and paper in flexible electronics.

We also performed studies of nanocrystalline TiO₂ layers deposited via thermal inkjet printing technology through an improved formulation of specific water based inks. We investigate the influence of deposition parameters on the electronic, optical and structural properties of these inkjet printed DSCs.

The use of the inkjet printing not only simplifies the patterning process, but also reduces the materials and energy consumption, facilitating the scaling-up from lab prototype device to large scale production of as well electrochromic and photovoltaic devices.