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Media Hub for Organic, Flexible and Printed Electronics

Smart Living & Mobility

New developments and latest products

LOPEC 2024

The world of printed electronics united in Munich

Henkel

Customer Event in Düsseldorf

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"Printed, flexible & hybrid electronics is everywhere"

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PRO Flextronics – Your new media hub for organic, flexible and printed electronics



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Martin Hirschmann

He has more than a decade of experience in writing about converting and printed electronics. Podcasts, hosting live events and online reporting are also part of his repertoire!



Nina Pirchmoser

She boasts long-term experience as media sales manager in the Converting and Flextronics industries. Company visits and networking at leading industry events are a mainstay in Nina's professional philosophy. She thrives on personalised and individual customer service and advice.



Nadine Bauernfeind

She brings her long-standing experience with various magazines into this project. Nadine has her core competences in design, typesetting and layout. With her keen sense for colours, shapes and motives, she puts the icing on the cake, when it comes to graphic design.

Welcome to your new Media Hub for Organic, Flexible and Printed Electronics!

Dear Readers,

Flextronics is family! For over a decade, we have met at industry events and tradeshows. Together, we have seen this industry grow into a force to be reckoned with. Together, we have witnessed ups and downs, successful projects, mass market adoptions – and collaboration in all parts of the value chain.

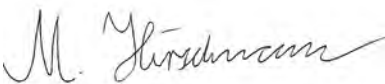
Together with you, we are now taking the next step: we proudly present to you our **PRO Flextronics PREMIERE**, the very first print product in our recently launched publishing house M2N Media GmbH.

We want to take media coverage of the flextronics industry to the next level: independently researched, flexible, quick, versatile, and – most importantly – personal. We believe in the power of digital media, as the ideal boost to our print issues. And: we believe that nothing beats human interaction in the B2B sphere!

With these introductory remarks, I want to invite you to read the following pages. The LOPEC main topics of “Smart Living and Sustainability” will play a major role in this PREMIERE issue. Moreover, we will look back at a customer event at Henkel in Düsseldorf, as well as some highlights of CES 2024 in Las Vegas.

We are excited for this next chapter that we just started – and with you, the Flextronics Family, I am certain that our new brainchild will turn into a success story. We are more than happy to hear from you again – just contact us on LinkedIn or via email – **or meet us directly at LOPEC (booth F0.15)**

Enjoy reading this issue!



Martin Hirschmann
Editor-in-Chief



 **Martin Hirschmann**
Editor-In-Chief

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www.proflextronics.com

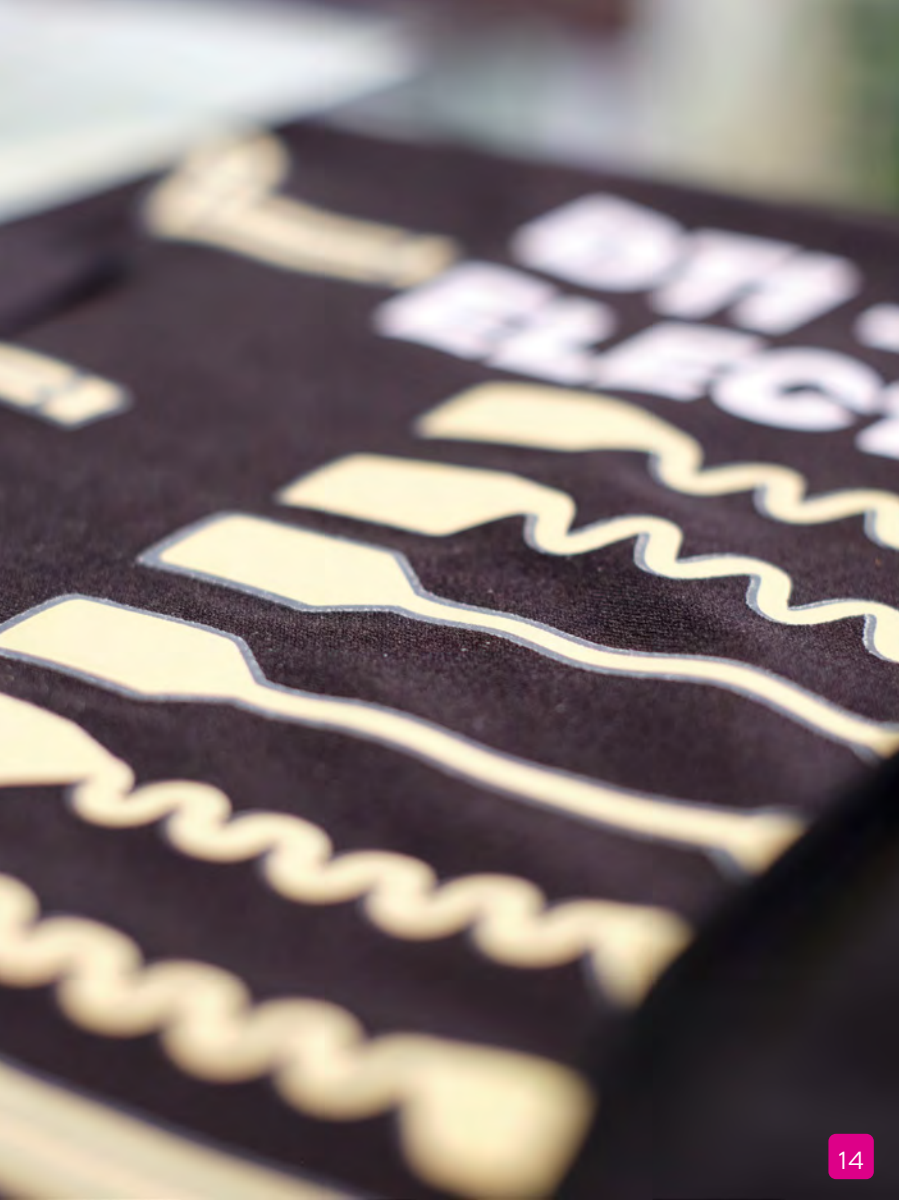
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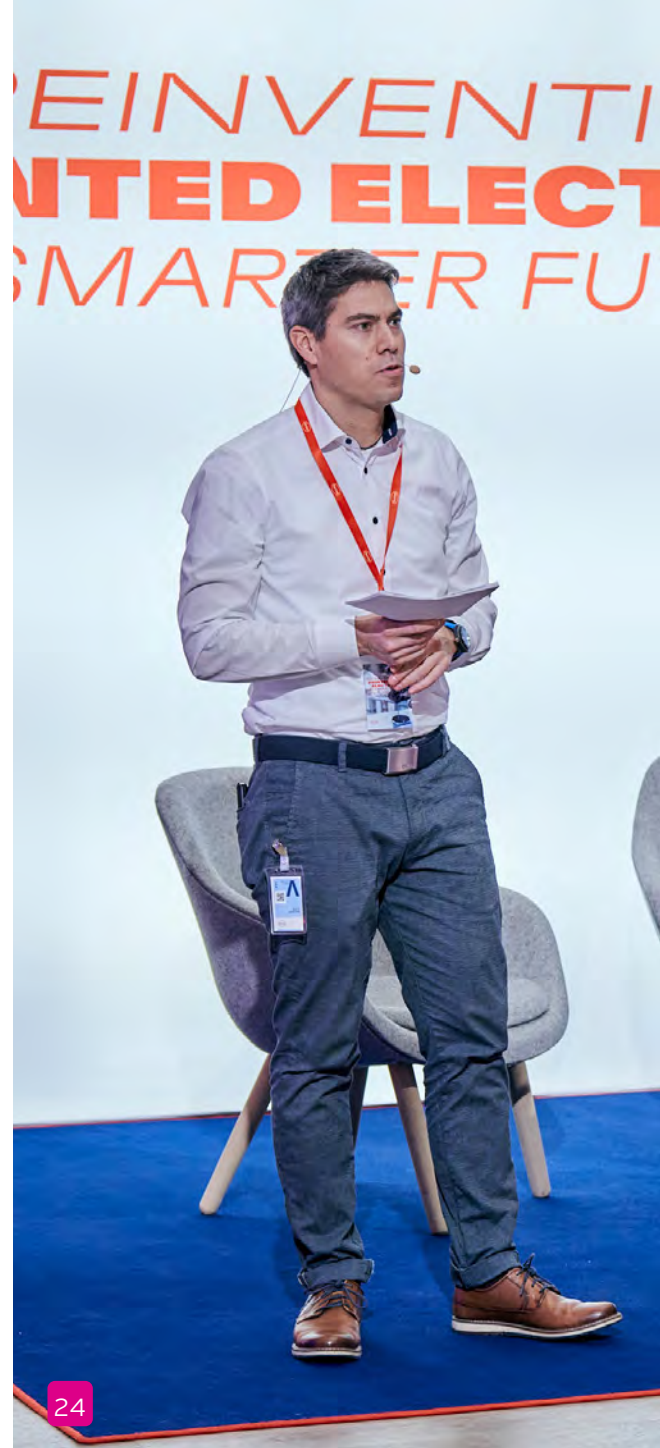




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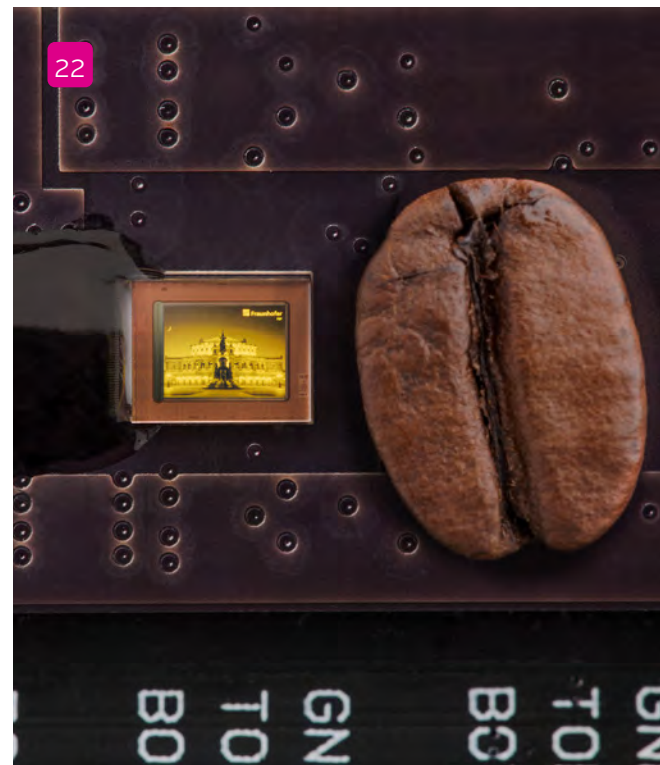
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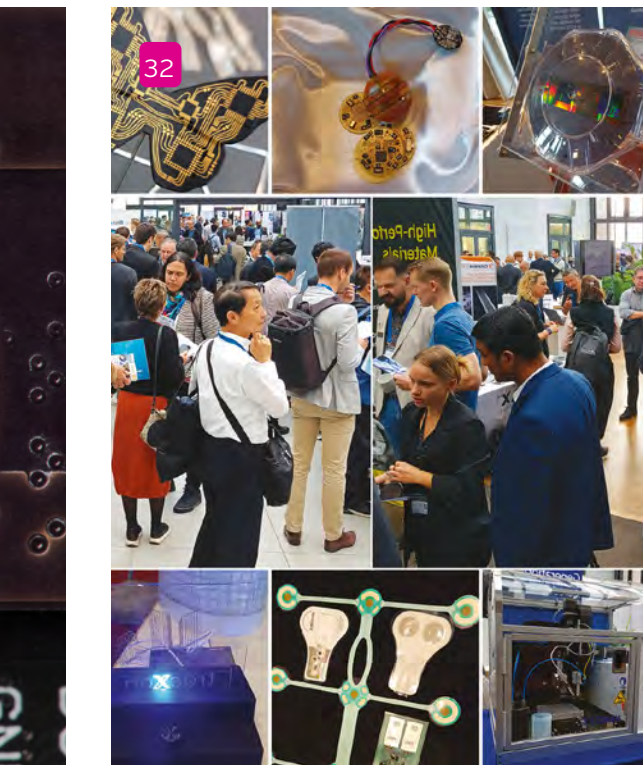
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LG Display’s automotive OLED displays receive ‘Product Carbon Footprint’ Certification

LG Display, a leading innovator of display technologies, has recently announced that its automotive OLED displays have become the first to receive the ‘Product Carbon Footprint (PCF)’ certification for automotive OLED displays from TÜV Rheinland, a leading global independent testing, inspection and certification body. This certification has been granted to two models (Auto Display Module – Base Model) for complying with the International Standard for Carbon Emission Measurement (ISO 14067:2018) and undergoing TÜV Rheinland’s critical evaluation of carbon emissions generated from design to production and disposal.



By incorporating LG Display’s independently developed ‘Light Control Film Integration Technology,’ the film enhances visibility by controlling the direction of light within the panel, which also reduces its carbon emissions by up to 18% compared to previous standards. Added benefits of this technology include production simplification, reduced weight, and enhanced energy efficiency compared to conventional panels that use external films.

LG Display’s Light Control Film Integration Technology is being applied to the company’s automotive display products such as P-OLED and Advanced Thin OLED (ATO). P-OLED utilises a flexible plastic substrate to achieve a slim, lightweight, and flexible panel that consumes 60% less power and is 80% lighter than most LCDs. “By making our differentiated technologies, such as Tandem OLED and SPM (Switchable Privacy Mode), more environmentally friendly, we are further cementing our position as the global leader of automotive displays,” said Keuk-sang Kwon, Vice President and Head of Auto Product Development Division at LG Display.

 www.lgdisplay.com
Image source: LG Display


Pragmatic Semiconductor partners with Intralink to target Japan

Intralink Limited has been selected to drive growth in Japan for UK scaleup Pragmatic Semiconductor, following the £182 million venture investment the company secured in December.

Cambridge-based Pragmatic Semiconductor develops chips based on innovative, flexible integrated circuits that are thinner than human hair. Made from polymers, they are quicker to produce than silicon chips, at a fraction of the cost and with a significantly smaller environmental footprint. The venture financing the company recently obtained is the most ever invested in a

European semiconductor firm, and sees Pragmatic now valued at around £500 million.

The investment is reported to enable the company, which currently has around 250 employees, to ramp up its UK production facilities, creating 500 new jobs and billions of chips a year – putting it on track to become Britain’s biggest chip maker.

 www.intralinkgroup.com
www.pragmaticsemi.com

Oxford PV sets new solar panel efficiency world record

Oxford PV, a pioneer in next-generation solar technology, has set a new record for the world's most efficient solar panel, marking a crucial milestone in the clean energy transition. Produced in collaboration with the Fraunhofer Institute for Solar Energy Systems, the panel achieved a record 25% conversion efficiency, a significant increase on the more typical 24% efficiency of commercial modules.

With solar power accounting for three-quarters of renewable capacity additions worldwide in 2023, increasing the efficiency of solar panels has transformative potential in the drive towards net zero and an all-electric future. As

the installation of solar power continues to gather pace, more efficient solar panels will generate more power over the same area, reducing the cost of electricity and further accelerating the adoption of clean energy.

Oxford PV, a spin-out of the University of Oxford, is a world leader in the development of perovskite-on-silicon tandem solar cells, which have a theoretical maximum efficiency of over 43%, compared to less than 30% for silicon solar cells.

David Ward, Chief Executive Officer, Oxford PV, said: "This new world record is a crucial milestone for Oxford PV, proving that our tandem solar cells can deliver record-breaking performance when assembled into solar panels. "It is the first step in what will be a transformative 2024, as we begin to deliver market-ready panels from our factory in Germany and continue our global search for a new high volume manufacturing site which will enable us to bring our technology into the mainstream."



Image source:

Fraunhofer Institute for Solar Energy Systems
www.oxfordpv.com

Heliatek supplies Austria's largest OPV installation

Solar film pioneer Heliatek, which is based in Dresden, Germany, has completed its first OPV installation in Austria. Together with their partner SPI Intelligence Services, they have realised a large-scale rooftop installation at Wien Energie's power plant in Vienna Simmering. Close to 350 HeliaSol solar films have been installed with metal sheets on a corrugated rooftop of a storage facility of the power plant. The lightweight HeliaSol solar films were the perfect choice due to the load capacity of the building.

Lars-Oliver Schröder, Head of Sales & Marketing Heliatek: "A big thank you to our partner SPI Intelligence Services for this wonderful project. Wien Energy GmbH is fascinated with our solution designed to enable ultra-green power generation on virtually any building surface." Martin Ruzicka, CTO SPI Intelligence, added: "As Heliatek's proud partner, we want to bring innovative solar films to Austria to enable more customers to become energy-independent with the greenest of all solar technologies. This largest installation in Austria is just the start of more projects with innovative solar films made in Dresden."



Image source: Heliatek
www.heliatek.com



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Head-Start at Henkel

First major industry event in 2024

January is traditionally considered to be a “slow month” in our team: not too many events, barely any tradeshows at all. The team at Henkel Printed Electronics aimed to change this perception on 16 January with its customer event for the PE industry. PRO Flextronics was invited to Düsseldorf, joining an impressive list of international decision-makers.

Read more on pages 24-26



Image source: Henkel
www.henkel.com

Texas A&M University

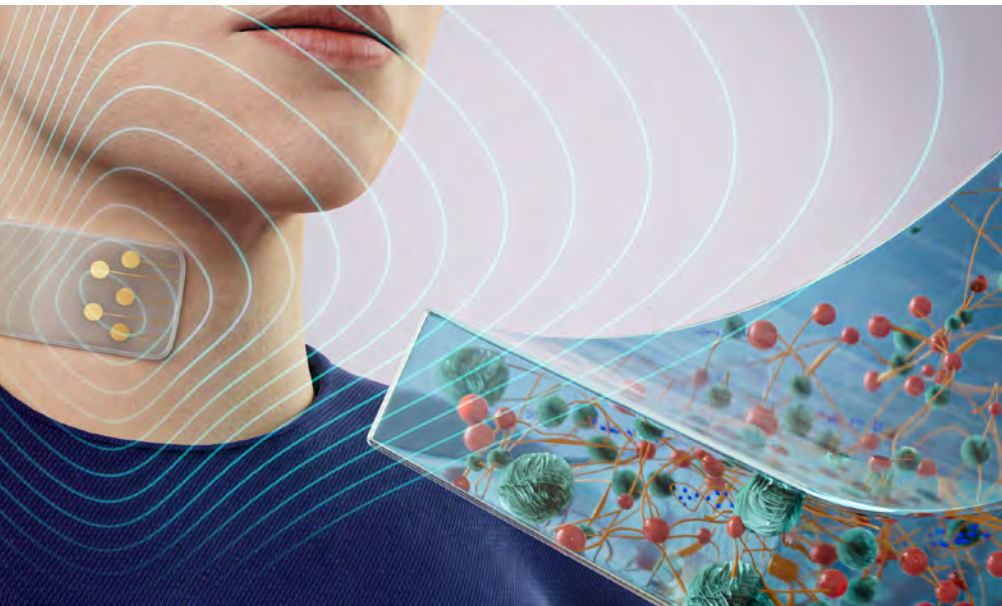
3D printed electronic skin – a promise for human-machine interaction

By utilising nano-engineered hydrogels that exhibit tunable electronic and thermal biosensing capabilities, researchers at Texas A&M University have developed a 3D-printed electronic skin (E-skin) that can flex, stretch and sense like human skin.

With more than 1000 nerve endings, human skin is the brain's largest sensory connection to the outside world, providing a wealth of feedback through touch, temperature and pressure. While these complex features make the skin a vital organ, they also make it a challenge to replicate.

versatile interfaces between technology, the human body and the environment," Gaharwar said. "The most exciting aspect of this research is its potential applications in robotics, prosthetics, wearable technology, sports and fitness, security systems and entertainment devices."

and creating mechanical mismatch at the biotic-abiotic interface," Deo said. "We introduced a 'triple-crosslinking' strategy to the hydrogel-based system, which allowed us to address one of the key limitations in the field of flexible bioelectronics." Using nanoengineered hydrogels addresses some of the challenging aspects of E-skin development during 3D printing due to hydrogels' ability to decrease viscosity under shear stress during E-skin creation, allowing for easier handling and manipulation. The team said this feature facilitates the construction of complex 2D and 3D electronic structures, an essential aspect of replicating the multifaceted nature of human skin. The researchers also utilised 'atomic defect' in molybdenum disulfide nano-assemblies, a material containing imperfections in its atomic structure that allow for high electrical conductivity, and polydopamine nanoparticles to help the E-skin stick to wet tissue.



Replicating the sense of touch

"The ability to replicate the sense of touch and integrate it into various technologies opens up new possibilities for human-machine interaction and advanced sensory experiences," said Dr. Akhilesh Gaharwar, professor and director of research for the Department of Biomedical Engineering. "It can potentially revolutionise industries and improve the quality of life for individuals with disabilities." Future uses for the E-skin are vast, including wearable health devices that continuously monitor vital signs like motion, temperature, heart rate and blood pressure, providing feedback to users and helping them improve their motor skills and coordination. "The inspiration behind developing E-skin is rooted in the desire to create more advanced and

The E-skin technology, detailed in a study published by Advanced Functional Materials, was developed in Gaharwar's lab. Drs. Kaivalya Deo '22, a former student of Gaharwar and now a scientist at Axent Biosciences, and Shounak Roy, a former Fulbright Nehru doctoral fellow in Gaharwar's Lab, are the paper's lead authors. Creating E-skin involves challenges with developing durable materials that can simultaneously mimic the flexibility of human skin, contain bioelectrical sensing capabilities and employ fabrication techniques suitable for wearable or implantable devices.

Triple crosslinking strategy

"In the past, the stiffness of these systems was too high for our body tissues, preventing signal transduction

Nanoparticles as crosslinkers

"These specially designed molybdenum disulfide nanoparticles acted as crosslinkers to form the hydrogel and imparted electrical and thermal conductivity to the E-skin; we are the first to report using this as the key component," Roy said. "The material's ability for adhesion to wet tissues is particularly crucial for potential healthcare applications where the E-skin needs to conform and adhere to dynamic, moist biological surfaces." Other collaborators include researchers from Dr. Limei Tian's group in the biomedical engineering department at Texas A&M and Dr. Amit Jaiswal at the Indian Institute of Technology, Mandi. The study is funded by the National Institutes of Health, the Department of Defense and the United States-India Educational Foundation.

Image source: INMYWORK Studio
<https://engineering.tamu.edu>

TINKER

3D Lidar-on-chip

The TINKER project aims to establish the fabrication of sensor packages enabled by additive manufacturing. Now that the project approaches its conclusion, the involved partners will present a demonstrator at the upcoming LOPEC 2024 tradeshow.

Three years ago, the EU-funded project TINKER (GA n° 958472) set out the goal to explore new approaches to the fabrication and assembly of sensors and microelectronics. As the project reaches its final month, one of the biggest achievements – a miniaturised OPA-based LiDAR sensor – will be showcased as a demonstrator at the LOPEC 2024 Trade Fair (booth B0.603). Attendees at LOPEC can visit the TINKER team to interact with this demonstrator, discover how new innovative techniques, such as nano-imprint lithography, were employed, which new materials were developed and tested, and how the final 3D-packaging resulted in such a compact design.

Final integration

Furthermore, the TINKER consortium will introduce the possibilities for the final integration into the car headlights, following current market trends. In a press statement for PRO Flextronics, the TINKER team addressed LOPEC visitors directly: “We are looking forward to discussing the performance of the newly developed system in correspondence to Advanced Driving Assistance Systems (ADAS) specifications and the future of TINKER technologies in autonomous vehicles.”




The demonstrator made by TINKER



Autonomous driving and self-driving cars represent one prominent example of the use of microelectronics and sensors, most importantly RADAR and LiDAR sensors. Their respective markets have a big potential.

The public awareness and the industrial need for further miniaturization of such sensor packages is the main driver of ongoing efforts in the automotive sector to be able to integrate such devices into the car body like in the bumpers, grilles and exterior lamps (headlights & rear lamps) instead of attaching them (e.g., on top of the car in case of LiDAR device).

Safety (for the driver and others) is the most important key aspect of the automotive sector. Therefore, high-value and high-performance RADAR and LiDAR systems are required for advanced driver-assistance systems (ADAS) as well as autonomous cars. Current bottlenecks are the relevantly large size of such sensor devices, their weight and power consumption. Since these factors are highly limited within cars, further miniaturization improving functionality and efficient use of resources is highly demanded.

 Image source: TINKER

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ams OSRAM

Unveiling a new family of automotive signalling LEDs

ams OSRAM, a global leader in intelligent sensors and emitters, launched a series of sidelooker, low-power LEDs that simplify design, are easier to implement and enable the creation of a homogeneous appearance in extended light bars and other automotive rear lighting applications.



Today, an automobile rear combination lamp (RCL) requires a complex and deep optical assembly consisting of diffusers and light guides to spread the bright points of light from conventional top looker LEDs without producing visible dark and bright spots.

By replacing top looker LEDs with the SYNIOS P1515 side lookers, automotive manufacturers can achieve a smooth, homogeneous appearance across the width of the vehicle. With the same number of LEDs as in a top looker-based arrangement, an RCL or turn indicator can be produced with a far thinner and simpler optical assembly. This opens up new potential to create dramatic and distinctive shapes in new RCL designs.

Substantially fewer LEDs

Alternatively, a homogeneous appearance can be achieved with the same depth of optical stack as for top looker LEDs, but with substantially fewer LEDs and LED drivers. With this option, the lamp manufacturer benefits from a reduced bill-of-materials cost and a simpler circuit configuration.

"With the introduction of this side looker innovation, ams OSRAM is bringing new value to manufacturers of automotive rear lighting – it enables superior optical performance at lower cost. ams OSRAM simulations indicate a design based on the SYNIOS P1515 can reduce the number of LED units and drivers required by as much as 66 percent compared to equivalent top looker-based designs while maintaining a very high level of homogeneity," said Michael Lobenhofer, Product Marketing Manager for automotive exterior lighting at ams OSRAM. "The innovative operation of the SYNIOS P1515 LEDs also enables the design of new super-sleek rear light bars that enhance the aesthetic appeal of the product to discerning car buyers."

Uniform 360° light intensity

The AEC-Q102 qualified SYNIOS P1515 LEDs produce a side-emission output with uniform 360° light intensity all around the device. Light is also emitted from the top of the LED, but at a lower intensity than from the sides, to ensure that applications such as extended rear light bars can be easily realised with no bright or dark spots.

The side-emission pattern of the SYNIOS P1515 LEDs is enabled by proprietary ams OSRAM optical packaging technology. ams OSRAM side looker LEDs are already widely used in backlighting for high-performance automotive displays. The SYNIOS P1515 family is available for sampling in red (621 nm), super-red (633 nm) and yellow (587 nm). Production volumes are available now.



Image source: ams OSRAM
<https://ams-osram.com>

Beneli AB

The future of wearable medical technology

Beneli develops the Gemini Patch. A conceptual innovative, wearable and stretchable printed electronics patch.



The Beneli team at work

In a world facing increasing health challenges, the need for innovative med tech solutions has never been more critical. Beneli AB, which is considered to be at the forefront of cutting-edge technology, as a renowned supplier of printed electronics, recognised the challenges faced by healthcare suppliers when it comes to stick-to-skin solutions. In response, they embarked on a journey to design a revolutionary adhesive medical patch – the Gemini Patch.

Challenges and the need

Traditional medical monitoring devices often pose discomfort and limitations in terms of wearability. Bulky sensors, adhesive issues, and inflexible designs have left much to be desired, hindering the adoption of continuous monitoring solutions. Beneli AB recognised these issues and sought to address them by innovating a wearable solution that would redefine patient monitoring.

Designing the solution

The design process began with a meticulous study of what was actually



Beneli's wearable and stretchable health patch

needed. The design process was marked by numerous cycles of refinement, iterations and challenges. According to the team, prototyping felt like stepping through a succession of doors, each unveiling fresh challenges. Throughout, they maintained a constant process of reevaluation, testing, and fine-tuning of their design, carefully balancing the needs and challenges with the choice of materials, adhesive strength, and the final functionality of the solution. To create a truly transformative product, the Beneli team formed by Amro Abu Zarour and Andreas Lindberg knew that the wearable device had to be both functional and comfortable.

Shape and stretchability

The team set out to create a wearable that could adapt to the body's contours without causing discomfort. This led to the development of a stretchable patch, maintaining contact with the skin even during movement and various activities. The stretchable design ensures that the patch adheres securely while also allowing for comfortable wear over extended periods.


Choice of materials and electrodes

The utilisation of the right electrodes allowed for versatile applications. Selecting the right materials was essential in achieving the desired functions, and yet each use case will have a unique design of materials and shape.

„We're proud to be at the forefront of wearable medical technology. The future of wearable medical technology holds the promise of transforming healthcare as we know it, seamlessly integrating data-driven insights into our daily lives and empowering individuals to improve their well-being like never before,“ said Beneli's CEO, Henric Ungh.

A leap forward

Beneli AB's stretchable patch marks a significant leap forward in the realm of wearable medical technology. By addressing the challenges and needs of patients and healthcare providers, this innovative solution promises to redefine the mass-producing market of wearable stretchable patches. According to Beneli, with its design, stretchability, dry electrodes, adaptable electrode options, and commitment to patient comfort, the future of patient care is looking brighter than ever. As Ungh concludes, „Our commitment to creating a healthier, more comfortable future for patients remains steadfast. The stretchable ultrathin Gemini patch is a testament to our dedication to improving top-of-the-line printed electronics, we will always strive to be in the forefront of new technology and this stretchable patch with dry electrodes is just the beginning of what we can achieve.“

 Image sources: Beneli AB
www.beneli.com

Danish Technological Institute

Charting the future of wearables for digital health and patient monitoring



Anna Krzyzanowska

In the realm of healthcare, the convergence of technology and medicine has sparked a revolutionary shift towards more personalised and accessible care. At the forefront of this transformation is the Danish Technological Institute (DTI) and its Printed Electronics group, which has been pioneering in the domain of wearables, thereby significantly contributing to the development of digital health.

At the heart of this innovation lies printed electronics, a technology that epitomises the future of medical device manufacturing. It allows for the printing of electronic circuits and components onto various substrates, including the flexible and wearable textiles that are becoming increasingly central to modern healthcare solutions. This technique is pivotal in creating devices that are not only efficacious but also lightweight, adaptable, and financially viable. The DTI's Printed Electronics group has adeptly utilised this technology to fabricate wearables that meld into the fabric of daily life, thereby making the idea of continuous health monitoring an achievable goal for the wider population.



Wearables

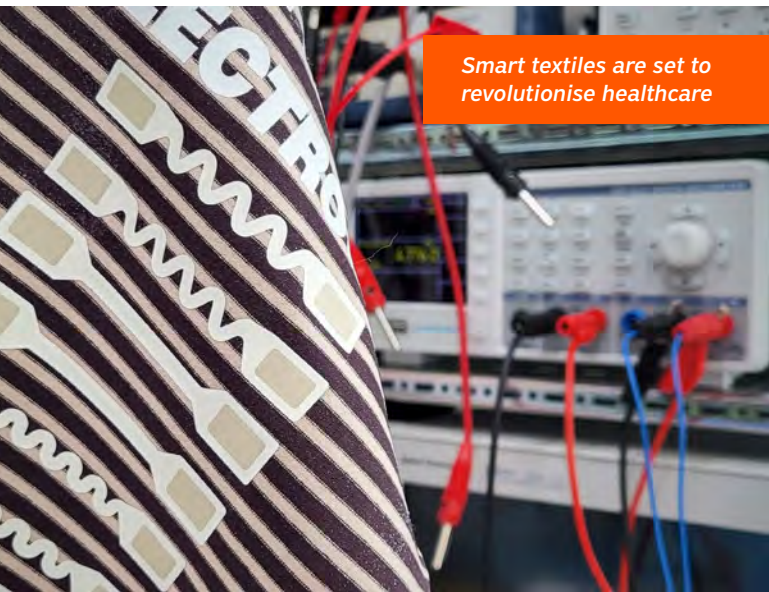
Wearable technologies represent a significant leap forward in healthcare, offering a diverse array of devices designed to be worn on the body with minimal intrusion. These devices are engineered for maximum comfort and minimal visibility, capable of performing a broad spectrum of functions that extend from monitoring physiological data to enhancing interpersonal communication and overall productivity. This development is instrumental in leveraging personal health data to drive improvements in healthcare outcomes, providing a foundation for more informed and effective medical interventions. DTI uses screen printing as a technique that can be used to deposit various materials onto a substrate, including fabrics. When applied to wearables, screen printing allows for the creation of electronic circuits and sensors directly on the textile surface. This method is particularly appealing for wearables due to its scalability, cost-effectiveness, and compatibility with flexible substrates. It enables the production of conductive patterns required for the functionality of wearable electronics without significantly altering the textile's flexibility or comfort.

Smart textiles: revolutionising healthcare delivery

The convergence of wearables with smart textiles and the screen-printing method heralds a revolutionary approach in healthcare. This holistic integration significantly enhances the capabilities for monitoring, prevention, and treatment, yielding solutions that are not only highly functional but also exceedingly user-friendly and comfortable. Embedding sensors and electronic devices into everyday clothing and fabric-based accessories enables non-invasive, discreet continuous health monitoring. This facilitates the real-time collection of critical health indicators, such as vital signs and other physiological data.



A printed EMG sensor



Smart textiles are set to revolutionise healthcare

Printed EMG sensor

One notable example of wearable technology development involves the Danish Technological Institute's work on printed Electromyography (EMG) sensors. EMG is a technique used to assess and record the electrical activity produced by skeletal muscles, utilising sensors to capture signals emitted during muscle contraction and relaxation. These printed EMG sensors, developed through advanced printing technologies, offer a new level of thin, flexible electrodes that ensure both comfort and wearability while providing invaluable data for a wide range of healthcare applications.

„This integration promises to improve health outcomes, provide personalised treatment, and reduce healthcare costs through advanced data analysis and machine learning algorithms. As technology continues to evolve, the potential applications and benefits of DTI's innovations in healthcare are set for significant expansion, emphasising their indispensable role in shaping the future of digital health and patient monitoring,” says Anna Krzyzanowska, Senior Specialist at the Danish Technological Institute.

Technology of the future

The Danish Technological Institute's relentless pursuit of excellence in wearable technology and smart textiles is carving out a new path for patient care, highlighting their indispensable contribution to the evolution of digital health and patient monitoring. Their work not only exemplifies the potential of integrating technology into healthcare but also sets the stage for future innovations that will continue to push the boundaries of what is possible in medical care and patient management. Persons on the quest to develop a digital health solution or a wearable solution for health applications can find an ideal partner in the Danish Technological Institute. “Our expertise spans the entire spectrum of design, development, and deployment of innovative healthcare technologies. We are dedicated to collaborating with healthcare professionals, researchers, and industry partners to bring cutting-edge solutions to the market, says Krzyzanowska. “Our team of experts is ready to work with you to transform your visionary ideas into tangible solutions that can lead to better health outcomes and digital health applications development.”

 Image sources: Danish Technological Institute
www.dti.dk

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FlexEnable

Flexible active optics evaluation kits for AR and VR

FlexEnable, a leader in the development and production of flexible organic electronics for active optics and displays, launches new optical evaluation kits for AR and VR devices.

The new kits made by the manufacturer from Cambridge, UK, include ambient dimming and tuneable lens film modules made using FlexEnable's flexible liquid crystal (LC) technology. These uniquely thin and light active optics are reported to bring game-changing optical performance to AR/VR and allow significantly smaller, lighter and curved devices — key factors in achieving the visual and physical comfort necessary for all-day wearability and sustained adoption. The evaluation kits are initially available to selected strategic partners who wish to evaluate FlexEnable's breakthrough technology for integration into new products. Chuck Milligan, CEO of FlexEnable, said: "Advancements in AR/VR technologies must simultaneously increase visual comfort and immersion, whilst allowing the devices to become lighter and smaller. Our uniquely thin and lightweight optical modules can modulate and focus light, ensuring virtual objects in AR appear solid and with high contrast and allowing users to comfortably focus on virtual objects at different distances."

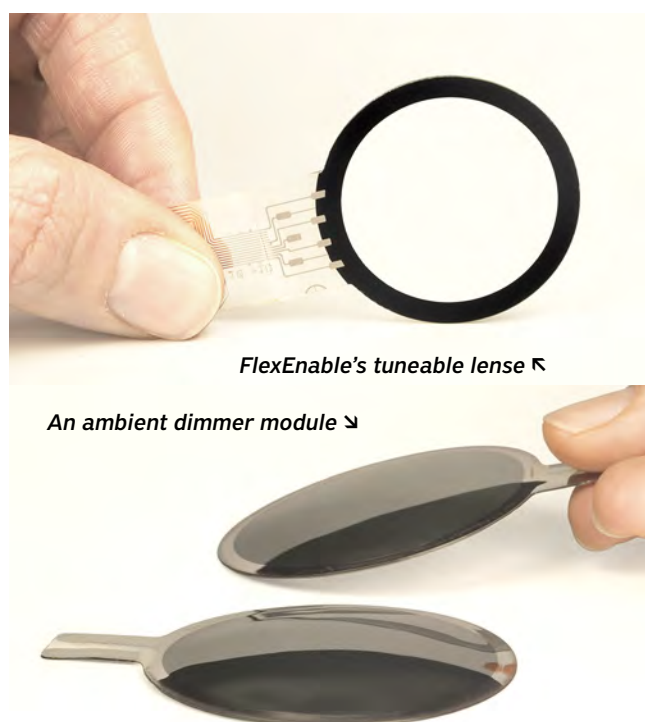
Customisable solutions

He continued: "For strategic OEM/brand partners we offer customisable solutions that can be integrated into new products, along with a rapid route to production scale-up through our existing manufacturing partners." The ambient dimmer module features a 50mm diameter aperture that switches in ~10 milliseconds, with a thickness of just 200 microns and a cell mass of less than one gram. It provides global dimming of unpolarised light for AR devices, and when integrated with FlexEnable's OTFT technology enables pixel-level dimming (spatial dimming). This allows virtual objects to be clearly visible and appear solid even as external lighting conditions change.



About FlexEnable

FlexEnable's award-winning flexible technology platform, together with their unique FlexIOM materials, brings transformational possibilities to products including AR and VR optics, ePrivacy screens, automotive smart windows and displays. The complete low-temperature manufacturing process allows, for the first time, commonly available and optically ideal flexible bio-degradable substrates such as TAC film to be used instead of glass. This innovative technology is used to make active-matrix flexible Organic Liquid Crystal Displays (OLCDs) and flexible active liquid crystal (LC) optical films which are thin, light and conformable to almost any surface. Today FlexEnable has around 600 patents and patent applications globally for OTFT and LC cell materials, processes, and architectures. The company has technology transfer programmes underway with several leading display manufacturers in Asia as well as commercial programmes with some of the world's biggest brands in consumer electronics.



FlexEnable's tuneable lens ↙

An ambient dimmer module ↘

High-end features

The tuneable lens module has a 30mm diameter with a continuously tuneable lens power of 0 to 1 dioptres, a cell thickness of 100-200 microns, and a mass of a fraction of a gram. It can actively adjust the focus of visible light, bringing perceived and actual image depth together consistently, by compensating for focal differences between the virtual and the real. FlexEnable's liquid crystal lenses can be stacked to increase focal power or combined with other flexible LC optical functions to provide additional features such as a dimmable lens. The active optical films can also be biaxially curved to follow the 3D contours of existing surfaces such as headset visors and fixed lenses, further reducing device volume and weight.



Image sources: FlexEnable
www.flexenable.com



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Printing Technology Wache

Major upgrade for doctor blade technology

Esterlam Advanced Doctor Blades have surfaced as pivotal players in the industry, providing unparalleled advantages and facilitating improved coating processes in the production of battery separators and electronic coatings. Printing Technology Wache (Görlitz, Germany) provides an overview in this technical article.

With the ongoing expansion of the new energy sector, there is an increasing need for innovative technologies and materials to address the rising demands for energy storage and sustainable solutions. For numerous years, Printing Technology Wache has served as the official agent providing technical support and direct sales partnerships for customers across various sectors of the packaging printing and coating industries.



i

The Esterlam portfolio can be purchased at Printing Technology Wache



Improved resilience and durability

Esterlam's E10+ laminated polyester blade is reported to be leading the industry with its enhanced spring and wear characteristics, rivalling steel blades in performance while eliminating the risks of abrasion and potential dangers. This groundbreaking advancement facilitates precise control and consistent coat weights, ensuring optimal performance and productivity throughout production. Through the A10 and A12 single substrate blade series, Esterlam demonstrates its dedication to versatility and adaptability in the new energy sector. These single-layer blades further enhance spring characteristics, guaranteeing even greater consistency and control during the coating process.



Introducing advanced polymer technology

Esterlam's commitment to integrating the latest polymer technology advancements has resulted in state-of-the-art blade designs. These innovations offer professionals in the industry improved spring characteristics, ultimately leading to reduced waste, increased yields, and higher productivity. Leveraging these advanced polymers provides operators with unparalleled control over their coating processes. Esterlam doctor blades feature self-lubricating properties, extending blade life when working with abrasive ceramic and graphite applications. This not only ensures cost-effectiveness but also reduces roller wear and scoring, thus minimising maintenance needs and downtime. With various profile options available, Esterlam doctor blades can be tailored to specific coating processes, setting new benchmarks in electronic coating technology. By enhancing consistency and control over coat weights, these blades enable manufacturers to elevate product quality and drive advancements in the new energy sector.

Enhanced chemical and thermal properties

Esterlam Advanced Doctor Blades exhibit superior chemical and thermal properties, making them ideal for use in battery separator production and electronic coatings. These blades



An Esterlam Advanced Doctor blade

consistently meet stringent requirements for performance and reliability. A significant advantage of Esterlam Advanced Doctor Blades is the elimination of steel blade particle contamination. This crucial feature guarantees the utmost cleanliness and purity in the energy manufacturing process, preventing any adverse effects on the final product's performance.

Conclusion

The increasing significance of new energy technologies demands state-of-the-art solutions that improve production processes, minimise waste, and boost efficiency. Esterlam Advanced Doctor Blades have established themselves as indispensable elements within the new energy sector, providing unmatched control, durability, and effectiveness. Through their inventive blade designs and advanced polymer technology, they pave the way towards a more sustainable and energy-efficient future. As the industry progresses, Esterlam maintains its position as the benchmark for electronic coating technology, catalysing advancements in battery separator production and other applications in the new energy realm.

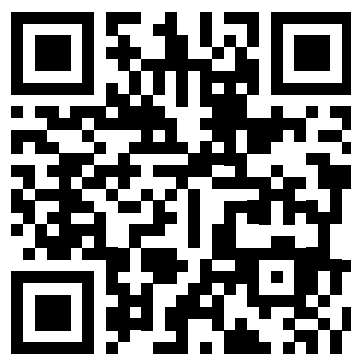


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www.printing-technology-wache.com

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Fraunhofer FEP

High-speed light modulation for OLED, micro-LED and LCOS arrays

High-resolution light modulators determine the graphical experience in virtual reality (VR) glasses or the performance in optical communication. A new backplane architecture for light modulation has been developed at Fraunhofer FEP, thanks to which extremely high refresh rates now lead to improved image quality and optical modulation.

Light modulators are used in applications such as optical imaging or laser control and communication to regulate and control the intensity, phase or polarisation of light. High-speed light modulation is also used in applications such as high-resolution displays, augmented reality (AR) and VR glasses. This allows clear images with low motion blur and a high refresh rate to be generated, resulting in an enhanced visual experience.

Microdisplays for AR and VR

Fraunhofer FEP has been developing microdisplays based on OLED-on-silicon technology for many years, which are designed specifically for each application. For AR and VR applications with high refresh rates, various displays with a sophisticated combination of power-saving backplane and optimised pixel densities have already been realised at the institute in recent years. Philipp Wartenberg, Head of IC and System Design, explains the latest developments: "Our newly developed backplane architecture greatly expands the possibilities for light modulation and exceeds previous refresh rates many times over. This is made possible by the integration of a complete frame buffer and a high-speed interface to the pixel matrix. This architecture

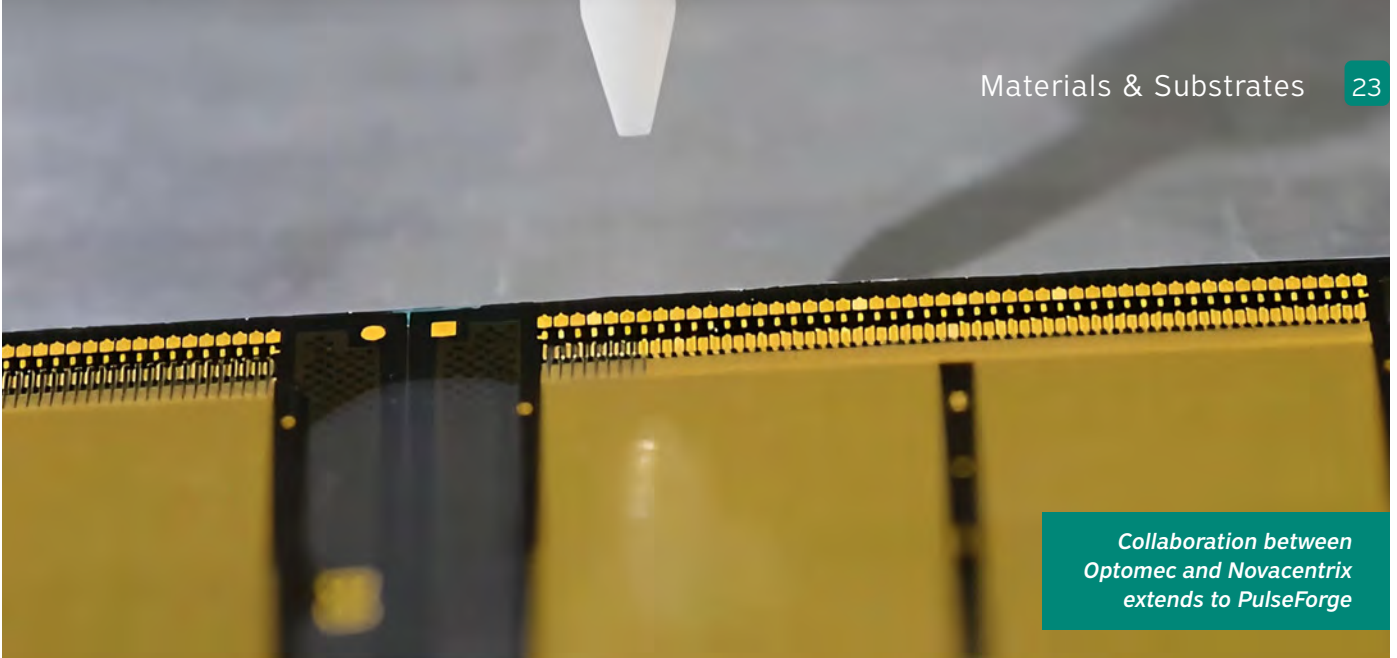
enables a data transfer rate of up to 576 Gbit/s to a pixel array with a resolution of 1440 × 1080 pixels and a pixel size of 2.5 µm for LCOS, OLED and micro-LED frontplanes."

Serving different front-plane technologies

In order to be able to offer application and customer-specific developments in addition to OLED-on-silicon technology to future partners and customers, the scientists at Fraunhofer FEP have designed the pixel control in such a way that it can serve various other front-plane technologies such as micro-LED or LCOS. The latter is particularly interesting for optical modulation applications. These developments were supported by public funds. Fraunhofer FEP thanked the Saxon State Ministry of Economic Affairs, Labour and Transport (SMWA) via the Sächsische Aufbaubank – Förderbank (SAB) for its support within the framework of the BACKPLANE project (100392259).



Image source: Fraunhofer FEP, Claudia Jacquemin
<https://www.fep.fraunhofer.de>



Collaboration between
Optomec and Novacentrix
extends to PulseForge

Optomec & Novacentrix

Revolutionising additive manufacturing

Optomec, a trailblazing provider of additive manufacturing systems for printed electronics, and NovaCentrix, a global leader offering high-performance conductive inks for additive manufacturing, announce their strategic partnership to propel the additive manufacturing Industry.

The long-standing collaboration between Optomec and NovaCentrix is reported to have redefined the landscape of printed electronics by harnessing the combined expertise of both companies to deliver cutting-edge solutions across a diverse spectrum of industries. Optomec's groundbreaking aerosol jet printing technology has positioned the company as a leader in additive manufacturing. With proficiency in printing electronics, including sensors and components, on various substrates, Optomec delivers cost-effective, high-performance solutions across diverse industries such as aerospace, automotive, medical devices, and consumer electronics.

Highly versatile inks

Complementing Optomec's capabilities, Metalon series inks by NovaCentrix, featuring silver, copper, gold and carbon variants, have established themselves as forefront choices within the industry for a wide range of applications. These highly versatile inks demonstrate exceptional suitability for printing on various substrates, including plastics (e.g., PET, polyimide), glass, metal, and paper. The collaboration between Optomec and NovaCentrix is poised to push the boundaries of additive manufacturing innovation, creating new possibilities for manufacturers. A pivotal aspect of this partnership is the strategic collaboration designating Optomec as a "preferred partner" for supplying ink with their aerosol jet printers. As part of this collaboration, Optomec bundles NovaCentrix's Metalon JS-A426 silver nanoparticle ink and other variants from NovaCentrix with their aerosol printers. This not only streamlines the procurement process for Optomec's customers but also serves as a valuable training resource, enabling customers to effectively use the aerosol printer while utilising the provided ink. Robert Yusin, CEO of Optomec, says "The partnership with NovaCentrix has been longstanding and strategic. The ability to work closely with a materials vendor such as this helps

us to deliver better output with our Aerosol Jet series of Printers. The combined offering of technology and materials gives us confidence in delivering industrial manufacturing solutions that can scale for mass production."

Charles Munson, CEO of NovaCentrix, echoes the enthusiasm, stating, "The collaboration between NovaCentrix and Optomec is an exciting step forward for the printed electronics industry. Together, we will push the boundaries of what is achievable, empowering manufacturers to achieve new levels of performance and efficiency."

Collaboration extends to PulseForge

Moreover, the collaboration extends to PulseForge, a spin-off from NovaCentrix and a leading provider of photonic curing equipment. PulseForge leverages intense pulsed light to rapidly cure and sinter inks for printed electronics, enhancing conductivity, reducing processing times, and lowering production costs. This pioneering technology swiftly transforms materials without jeopardising the integrity of the underlying substrate, making it an ideal solution for various applications. The partnership between Optomec and NovaCentrix promises to provide a groundbreaking solution for companies seeking to streamline their printed electronics manufacturing processes. By integrating aerosol jet printing with photonic curing, this collaboration aims to unlock opportunities for innovation and excellence in the ever-evolving domain of printed electronics.



Image source: PulseForge/Optomec
www.novacentrix.com
www.pulseforge.com
www.optomec.com

Henkel Printed Electronics customer event

Printed Electronics – shaping tomorrows innovations

On 16 January 2024, PRO Flextronics was invited to the Henkel headquarters in Düsseldorf, Germany, to attend a customer event focusing on printed electronics. On-site, our Editor-in-Chief sat down for an exclusive interview with Carla Negele, Head of Product Development, and Stijn Gillissen, Global Head of Printed Electronics.

PRO Flextronics: Let's start by talking about today's event. Please tell us about the idea and the ambition behind it

Stijn Gillissen: Our event is titled "Reinventing Printed Electronics for a Smarter Future". Today, we are bringing different customers and partners together to engage cross-industry and along the value chain, specifically focusing on future innovation. As I said on stage, successful commercial printed electronics applications are created from ecosystems. Markets are transforming and it is important to foster industry exchange, like we are doing today.



Stijn Gillissen



Henkel's Printed Electronics event brought numerous international customers and partners to Düsseldorf



PRO Flextronics: The motto for today is “Shaping tomorrow’s innovation”. Can you tell us what this means for the printed electronics business at Henkel?

C. Negele: There are many different perspectives when it comes to innovation. For us, this entails leaving our comfort zone, the material focus, to understand the broader market dynamics and transformation. Instead, we are focusing on future applications. What is important to our customers? What is important at end-application level, and how we can address the biggest needs in the industry?

S. Gillissen: With that being said, how can we add value and functionality to end applications with our portfolio of materials? When we talk about a battery, antenna, or any other application, the materials that we develop play an important part. Still, we also need to understand the importance of having better connectivity in an antenna, to name only one example. What happens if we improve the electrical conductivity by 20%? Does that improve the antenna performance? If this is not the case we need to reiterate the value add that our materials offer to the end-application. How do we best apply these materials in volume manufacturing? Most processes are based on screen printing today. However, there is a real need for high-volume applications. In conclusion, the real question is this: How do we tune our materials together with the process so that they can be applied and tailored to a specific application need? Always keeping the product lifecycle in mind.

PRO Flextronics: What is Henkel’s role in the printed electronics ecosystem?

S. Gillissen: At Henkel, we see our role as a key supplier of printed electronics materials for the industry. However, for printed electronics to succeed in newly evolving markets, there needs to be more than that. Because of this, we have a strong ecosystem of partners, ranging from printers to OEMs, that enable scalable printed electronics solutions.

PRO Flextronics: How close are we to printed electronics becoming successful?

Carla Negele: Next to new applications, I would like to highlight the new material requirements that come with the market transition. Especially if we want to come up with innovative materials, it is crucial to think of the complete product life-cycle. Sustainability is an integral product characteristic from raw material to the printing process to end-application and end-of-life. That’s why we aim to engage along the value chain, like we do today at our event.

S. Gillissen: Printed electronics have been enabling successful electronics applications for decades. It may still feel like a niche when comparing it to competing standard FPC or similar technologies. This is where overarching megatrends are changing the game. Printed electronics, a traditional electronics technology, is being reinvented to become an important component to cross-industry market innovation.

PRO Flextronics: Let’s talk about printed electronics in the overall context of Henkel Adhesive Technologies. How do you leverage Henkel to work cross-functionally and across industries?

C. Negele: We benefit from our size because many customers are looking for a complete material solution. By working together with other business units, we ensure that we can offer more than conductive inks and coatings. For instance, we can include different kinds of adhesives in our offer, etc. By working together within Henkel’s different units, we are able to offer the complete material solution as one single supplier!

S. Gillissen: While printed electronics in some markets may be considered as new technology platform, it is not new within Henkel. In fact, we have been selling printed electronics materials for 40 years!





Carla Negele

S. Gillissen: While we have the printed electronics technology, our colleagues from other business units have access to the respective markets.


PRO Flextronics: Let's talk a bit about the trends and applications that you currently observe or have in your focus. What's coming next for Henkel Printed Electronics?

S. Gillissen: Our set of material solutions targets diverse industry applications. For example, printed antennas are one application field we identified with large growth potential. The value of printing the antenna increases significantly compared to a PCB-type antenna, due to it being an additive technology. Additional growth markets are energy storage, with applications such as battery or solar, and smart surfaces and healthcare applications. Printed electronics technology can transform simple surfaces into functional surfaces. In an era of connectivity and digitalization, this is a true game-changer, but only if the solution is customer-centric and follows a sustainable market approach.

PRO Flextronics: What is the next event for Henkel Printed Electronics?

S. Gillissen: Our next event will be LOPEC 2024 in ICM - Munich, in Hall BO/Booth 607, where we will have a booth and be featured in the conference.

C. Negele: Our team will showcase the comprehensive Henkel portfolio of printed electronics materials with interactive demonstrators highlighting use cases, from printed antenna, to smart surfaces to healthcare. It is the event to attend when exploring printed electronics or looking for specific solutions!

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 Image sources: Henkel
www.henkel.com



LOPEC 2024

The world of printed electronics united in Munich

It's that time of the year again: our industry is preparing for the upcoming edition of LOPEC. PRO Flextronics has compiled all the information that you need to know ahead of your visit to the ICM at Messe Munich from 5-7 March 2024.

Highlights for flexible and printed electronics

It makes life easier for seriously ill patients, is indispensable for the mobility transition, and allows us to immerse ourselves even deeper in the metaverse: Printed electronics is both a key and a cross-sectional technology, as this year's LOPEC will demonstrate with numerous applications and presentations. The health sector in particular benefits from the possibilities offered by ultra-thin, lightweight, and flexible electronic components. LOPEC exhibitor Covestro, for instance, will be presenting wearable patches that wirelessly monitor a wide range of vital signs. The company has now even developed a sensor that registers moisture on an artificial stoma, making everyday life easier for those affected. Beneli from Sweden will be showing stretchable smart patches with embedded electronics that adhere securely over a long period of time, and even during movement, and measure the patient's heart rate and temperature, for example. The sensor socks from Metafas in the Netherlands, in turn, support the care of people with health impairments who have difficulty expressing their needs. They detect stress by measuring skin conductance.

Printed sensors for e-mobility and the metaverse

LOPEC highlights in the mobility sector include sensor systems for electric cars. Printed sensors monitor the temperature and pressure conditions in battery stacks, allowing cell-friendly and faster charging cycles to be developed. In battery balancing, sensors record the voltage level of the various cells to increase the performance and service life of the batteries. Products and information on printed electronics in e-mobility are available at LOPEC from sensor specialists such as IEE and InnovationLab, as well as Celanese,



Heraeus, and other material manufacturers. Anyone who wants to immerse themselves in the metaverse without a bulky remote control should also visit the Heraeus stand. Together with the Japanese start-up AI Silk, the company has developed a haptic glove with finger-bending sensors and control buttons that make virtual touch perceptible and also serves as a controller.

Focus on sustainability

As more and more products contain electronic components, issues about sustainability, recycling, and circular economy inevitably arise. Industry representatives and scientists from the U.S., Finland, Belgium, Switzerland, and Germany will address these aspects at the LOPEC Round Table on "Sustainability, circularity, and printed electronics" at the LOPEC Forum (6 March from 3 to 4 p.m. at the ICM Foyer). Many young companies are also working on solutions for a sustainable future. They will present their business ideas in ten-minute pitches at the LOPEC

Start-up Competition. The best business ideas will be honoured in two categories at the Award Show evening during the LOPEC Get-together on 6 March. All exhibitors, trade fair visitors, and conference participants are invited to attend.

LOPEC Conference: industry meets science

The new Open Plenary Session, a plenary lecture given by Dr. Alain Schumacher, CTO at sensor manufacturer IEE, is also free for all interested visitors (6 March 8 a.m., LOPEC Forum at the ICM Foyer). Entitled "Printed Electronics – Products, Trends and Facts for a Sustainable Future", it highlights the range of sustainable applications for printed electronics. The other plenary sessions which are part of the LOPEC Conference requiring an extra ticket, will also focus on the current challenges of our time. Karine Benbelaid, Global Segment Head Medical at Covestro, will discuss the circularity of medical technology components (5 March, 9 a.m.). Dr. Petra Severit, CTO at the specialty chemical company Altana, will describe how global megatrends – from digitalisation and the mobility transition to the transformation of our economy – can be successfully shaped using printed electronics (6 March, 9 a.m.). Another highlight of the LOPEC Conference will be the plenary lecture by Dr. Hiroki Maeda (7 March, 9 a.m.). As a representative of Dai Nippon Printing (DNP), one of the world's largest printing companies based in Shinjuku, Japan, he will discuss printed electronics for next-generation telecommunications. Alongside other speakers from the industry, scientists from all over the world will present their latest findings. It's worth taking a look at the programme since the three-day LOPEC Conference, with its synthesis of research and business, is the ideal complement to the trade fair.

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Image source: Messe München

“Actively shaping global megatrends with printed electronics”

At the LOPEC Conference, Dr. Petra Severit, CTO at the specialty chemical company Altana, will discuss how printed electronics can be used to master the challenges of our century. In this interview ahead of the conference, she explains why printed electronics boosts the power of solar cells, batteries for electric cars, and much more, and what innovations there are in the field of materials and functional inks.

PRO Flextronics: Dr. Severit, what role does printed electronics play for your company?

Dr. Petra Severit: A very important one. Printed electronics combines the know-how of printing technology with that of electronics, and Altana contributes the chemical perspective. Our Elantas division offers its own product line for printed electronics, with printing inks and services both for existing and entirely new applications.

PRO Flextronics: Which specific products for printed electronics are they?

Dr. P. Severit: The Elantas portfolio mainly comprises functional, in other words, conductive, insulating, and dielectric screen-printing inks. They offer optimised printing properties and are also flexible, thermoformable and high-temperature resistant. Especially in consumer electronics, we are helping manufacturers to build ever smaller and more powerful devices, thereby saving materials and energy. At the same time, our products help extend the service life of electronic components, which increases their sustainability.

In addition, our portfolio has expanded thanks to our acquisition of a stake in the start-up Saralon. As the exclusive partner of this young company, which specialises in the development of inks for printing electronics, Elantas primarily sells highly stretchable silver inks, a water-based copper ink, and a variety of conductive adhesives throughout Europe. Saralon's functional inks can already be used today to print batteries, for example.



*Dr. Petra Severit,
CTO at Altana*



PRO Flextronics: Where else are your products used?

Dr. P. Severit: The applications are diverse and can be found in the electronics sector, in household and other consumer appliances, but also in the packaging industry, the logistics sector, and vehicle construction. Established applications for printed electronics include, for instance, lighting, control elements and seat occupancy sensors in vehicles, or buttons on washing machines. Printed electronic sensors in electric car batteries measure temperature and pressure, among other things. If required, the battery can also be heated using printed heating elements—that, not least, reduces charging times and thus increases the service life of the battery.

PRO Flextronics: With reference to printed electronics, what is your company currently researching?

Dr. P. Severit: Altana is committed to a culture of innovation that is truly practised. We annually invest around seven percent of our sales in research and development. In 2022 alone, that amounted to 193 million euros. That includes investments in printed electronics. In the past few years, for example, Elantas has developed several products for particularly thin conductor track printing, so that both the conductor tracks and the spaces are as fine as 30 micrometres. That represents clear added value for our customers because it allows them to fit more functions into less space. We see a considerable advantage here, especially when it comes to printing solar cells, since the thinner conductors offer more surface area to absorb sunlight, and hence effectively increase the efficiency of solar cells. Printed heating elements are also currently very promising. They are being used in more and more applications in different sectors. Here we specialise in screen printing pastes that cover a temperature range of 55 to 200 degrees Celsius and can be printed on various plastics. Last but not least, we are also investing in disruptive printing technologies such as our laser-based digital printing process Heliosonic. It enables high-precision and material-saving printing, for example, on continuous formats.

PRO Flextronics: You will be giving a presentation at the LOPEC Conference. What awaits the audience?

Dr. P. Severit: I will be talking about how printed electronics can be used to actively shape global megatrends, and how our products can help consumers and companies not only cope with the disruptive developments of the 21st century—digitalisation, the demographic shift, the transformation of mobility and our economy toward greater sustainability—but also derive the greatest possible benefit from them.

PRO Flextronics: What do you expect from LOPEC?

Dr. P. Severit: Above all, we hope that LOPEC 2024 and the accompanying conference will lead to a fruitful exchange of knowledge and experience. We want to engage with customers and partners so that together we can give an even stronger push to launching the solutions offered by printed electronics on the market.



Image source: ALTANA
www.altana.com

March 5-7, 2024

LOPEC 2024

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Conference: March 5-7, 2024

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Armin Wittmann

Exclusive interview with Armin Wittmann, Exhibition Director of LOPEC

PRO Flextronics: Mr Wittmann, how would you describe the development of LOPEC in the last few years?

Armin Wittmann: The development of LOPEC reflects the development of the industry which continues to gain relevance as the technology is incorporated into more and more products. Last year we had an all-time high in exhibitor numbers with 168 companies and for LOPEC 2024 the registrations will even be slightly higher. Many exhibitors have decided to take part at an earlier stage than ever before, and some have booked larger stand areas. There are also many new companies, such as Beneli, CCL Design, the Linxens Group, Marabu GmbH, Production ToGo, Sefar and TESA. The LOPEC Conference has also enjoyed an unbroken interest for years and we are looking forward to about 170 carefully selected presentations.

PRO Flextronics: How are Smart Living and Mobility reflected in this year's LOPEC programme?

A. Wittmann: In addition to the issue of sustainability which runs like a common thread through LOPEC 2024, we are again focusing on the topics of Smart Living and Mobility. Exhibitors will, for example, show how printed electronics is making the health sector fit for the future: For instance, printed sensors for health monitoring are relieving healthcare professionals, smart labels for packaging and devices are enhancing brand protection and patient safety, and organ-on-chip-systems which are designed

to replace animal testing, are performing better thanks to printed electronics and have become an unbeatable tool for accelerating drug discovery and development. Printed electronics is also driving innovation in the automotive sector. Examples on display include new safety features for autonomous driving such as a hands-on/off detection, efficient heating concepts for car interiors, windscreens and headlights, and special printed electronics devices that improve battery performance and service life.

PRO Flextronics: Who should attend LOPEC, and what are the best reasons to come to the event?

A. Wittmann: A visit to LOPEC is a must for technology leaders and anyone interested in making their products greener, lighter, cheaper and more digital. LOPEC provides a complete market overview of flexible, organic and printed electronics as well as cross-industry information along the entire value chain. Visitors will be able to see up close concrete solutions using this key technology as well as the enormous potential it still holds for the future. We are delighted that LOPEC is helping to shorten the time-to-market for this sustainable technology. As the most important platform for the industry, LOPEC is where experts from science and industry come together to network, make new business contacts and exchange their knowledge.



Image sources: Messe München
www.lopec.com

CES 2024

The global platform defining our future

CES 2024 has closed, after an exhilarating week that set the technology narrative for the year ahead. With 4300+ exhibitors, including a record 1400+ startups from around the globe in Eureka Park, CES showcased the innovative trends shaping tomorrow and solving the world's most pressing challenges.

“The resurgence of CES proves that face-to-face conversations and meetings are a necessity for the technology industry,” said Gary Shapiro, president and CEO, Consumer Technology Association (CTA). “For more than 20 years, I’ve said that every company must become a tech company, and the diversity of exhibitors at CES 2024 proves it. The CES footprint and conference programming span the entire tech ecosystem.”



CES 2024 by the Numbers

- » 2.5+ million net square feet of exhibits, 15 percent bigger than CES 2023
- » 4300+ exhibitors, including 1400+ startups within Eureka Park
- » 135,000+ attendees, a record 40+ percent from 150 countries, regions and territories
- » 5000+ global media and content creators
- » 60% of Fortune 500 companies
- » 250+ conference sessions with 1000+ speakers
- » CES 2024 Innovation Awards programme received 3000+ submissions, a record high, and included AI as a new category
- » 25,000+ pieces of media content led to 160+ billion impressions of CES 2024

“CES 2024 brought the ALL ON experience for media, executives and industry thought leaders. Across the show and on CES conference stages, thousands of global brands announced new visions, products, investments and partnerships,” said Kinsey Fabrizio, CTA Sr. VP, CES and membership. “Technology is solving global challenges, and we’re excited to see so many collaborations and partnerships start here in Las Vegas, and produce a show where attendees come to meet, dream and solve.”

CES 2024 Flextronics Highlights

Dracula Technologies, a pioneer in harvesting energy from indoor light, has introduced LAYER Vault at CES in Las Vegas. This groundbreaking technology, the world’s first of its kind, seamlessly combines low-light Organic Photovoltaic (OPV) energy harvesting and electrical storage on a single flexible film. LAYER Vault is set to revolutionise the electronics industry by providing a sustainable and cost-effective alternative to traditional batteries, enabling unprecedented energy autonomy for IoT and ultra-low-power products. This marks a significant milestone for OEMs, device makers, integrators, and IoT solution providers, simplifying design processes and reducing the Total Cost of Ownership (TCO).

LG Display, a leading innovator of display technologies, has been showcasing a series of ultra-large automotive display solutions, including the world’s largest automotive display, to accelerate innovations for future cars at CES 2024. At its dedicated booth for automotive displays in the West Hall of LVCC, LG Display unveiled the world’s largest automotive display, the ‘57-inch Pillar-to-Pillar (P2P) LCD,’ and largest slidable panel, the ‘32-inch Slidable OLED,’ for the first time.

Epishine, a leading energy impact company, and **Nichicon**, the world’s leading capacitor manufacturer, have deepened their strategic partnership with the introduction of a revolutionary self-charging battery concept. This concept aims to simplify the design of light-powered electronics, providing a power solution as easy to integrate as traditional batteries. In doing so, it addresses sustainability, usability, and cost-related concerns, marking a significant stride towards a new era in powering electronics.



Dracula Technologies’ LAYER Vault

Image sources: Dracula Technologies, CTA
www.ces.tech

As you shall see, printed, flexible, hybrid electronics is everywhere. Indeed, the applications discussed here represent a diverse and sometimes disparate set of technical demands, market conditions, and even manufacturing and material requirements, even though they all fall under the umbrella of printed, flexible, and hybrid electronics. For each application, I will also aim to give a sense of the frontiers, sketching how requirements and technologies are evolving and/or changing.

It is important to recognise the diversity and the existing successes of this industry since many applications cease to be called printed electronics once they are successful, leading to a common misconception that characterises the printed, flexible, hybrid electronics as only a yet-to-emerge technology of the future.

To appreciate the growing successes and the wonderful diversity of this industry, we invite you to join the TechBlick Future of Electronics RESHAPED events in Boston (12 & 13 June 2024) and/or Berlin (23 & 24 October 2024) where the entire global industry learns and connects.

Photovoltaics – manufacturing capacity reaches 1000GW?

Let us begin the journey with photovoltaics, which are growing at a breakneck pace. According to the IEA, in 2022, global PV manufacturing capacity increased by more than 70% to nearly 450 GW, with China accounting for more than 95% of new additions across the supply chain. The growth continued at an unabashed pace, with the IEA expecting the global manufacturing capacity in 2024 to reach an incredible 1000 GW.

Screen printing silver pastes have a near complete market share for metallizing silicon photovoltaics. The amount of silver per cell – and consequently per watt – for front and rear metallization has declined. In 2023, it stood for PERC photovoltaics (the dominant technology) at around 10 tonnes per GW. Given the expected manufacturing capacity in 2024, this could translate to around 10,000 tonnes of silver (and more of paste depending on loading etc) per year!

This is also an incredibly advanced printing technology. This field can already execute ultra-fine line printing at scale. In 2022, the linewidth of the printed

“Printed, flexible and hybrid electronics is everywhere”

In this article, Dr Khasha Ghaffarzadeh, CEO at TechBlick, demonstrates the depth and breadth of printed, flexible, and hybrid electronics, taking you on a journey that covers existing and emerging applications in a diverse range of fields, including photovoltaics, displays, human-machine interfaces, electronic manufacturing, medical devices, sensors, electronic components, and many others.



Dr Khasha Ghaffarzadeh

fingers was around $30\mu\text{m}$ with ca. $10\mu\text{m}$ alignment precision as standard in manufacturing. This is projected to be further narrowed, reaching a linewidth of $15\mu\text{m}$ with $5\mu\text{m}$ alignment precision in 2032 to reduce the amount of expensive silver per cell. In R&D and pilot settings, such screen-printed line widths are already being demonstrated with printed bus bars exhibiting incredible aspect ratios. To illustrate the progress, note that the state-of-the-art publications just a decade ago were reporting linewidths at $80\text{--}100\mu\text{m}$!

What is more incredible is that these ultrafine lines are printed at incredible speed to maintain high production speeds. Indeed, the screen-printing system in 2022/2023 could achieve >7500 wafers per hour (M10 wafers: $182\times 182\text{mm}^2$). The industry roadmap sees this increasing to over 10 000 wafers per hour (with $15\mu\text{m}$ linewidths!).

These numbers are incredible technical and manufacturing achievements, and are a testimony to the inexhaustible innovation power of the screen printing ecosystem – from mesh and screen manufacturing to material and machine developers – to cooperate and push the performance to new heights.

Going beyond silicon photovoltaics

Many photovoltaic technologies are in development, seeking to complement and/or replace silicon in specific fields. Two prominent options are organics and perovskites. For both, printing is likely to be the main method of manufacturing the cells and not just for metallization.

The former has a much longer development history with several cycles of high hope followed by deep disillusionment. The latter holds extremely high promise, both as a standalone and tandem technology, provided manufacturing and stability issues can be addressed. Both technologies offer newcomers and new territories ways to break into the vast solar market dominated by China and silicon technology.

For organics, currently, automated R2R printing is being scaled up, especially in Europe, building upon decades of accumulated ecosystem expertise to simultaneously establish a high-throughput process as well as a roadmap of niche markets that may, after over two decades of development, allow this technology to finally become commercially competitive.

For perovskites, printing will likely play a pivotal role as perovskite active layers can come in ink format and be solution-processed. Indeed, many around the world are today establishing hybrid printing lines to manufacture perovskites. Hybrid here means that not all layers will be printed, but the production will include R2R printing and other vacuum processes.



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There are many innovation and development opportunities here. Stable and highly efficient inks with friendly solvents and rapid curing properties are required, and high-speed printing as well as vacuum and laser processes are needed to print solar cells at scale. At the same time, fundamental challenges, in particular around the issue of long-term stability, must be addressed. Luckily, the worldwide momentum here is strong and the market pull is even stronger, increasing the chance of ultimate success.

Printing in displays

Inkjet printing is already an established part of OLED display manufacturing, where industrial-scale inkjet printers are used to deposit the organic material in the multilayer thin film encapsulation (TFE) layer that protects OLEDs from oxygen and water ingress.

Inkjet printing the RGB active materials in OLED displays, however, seems not to have succeeded in overcoming the technical hurdles despite significant investment and decades of development on both material and machinery sides. It appears that the material performance never bridged the gap with vacuum-processed ones, which kept on improving, whilst the potential manufacturing cost benefits proved insufficient to force a shift away from the incumbent processes.

This is not the end of inkjet printing in manufacturing the active elements of the display though, thanks mainly to quantum dots (QDs) including QD-OLED and QLED displays. The idea behind QD-OLED displays is that a blue OLED layer is vacuum deposited, whilst the red and green colours are achieved by pixel-level inkjet-printed QD colour conversion, giving the emissive display perfect contrast, high efficiency, as well as a very wide colour gamut, beyond what all-OLED displays could achieve. Mastering the inkjet printing of QD-OLED displays could also offer a technical and manufacturing roadmap towards true emissive QLED displays.

Mini- and MicroLEDs – from micro bumps to microLED transfer to colour conversion

Mini- and micro-LED technologies could also benefit from printing. Here, the micro bumps for the placement of a large number of microLEDs on the glass substrate could be printed. Indeed, excellent prototypes were already demonstrated with gravure offset printed solder pastes with 5µm precision and 6µm diameter (15µm after reflow).

The metallization tracks connecting the front and back of the mini- or micro-LED display via the edge of the glass hosting the microLED chips could be screen or aerosol printed to avoid drilling and

Impressions from TechBlick Berlin 2023



metallizing through-glass vias, although it will probably prove too difficult to beat the incumbent subtractive process given the resolution speed, and yield requirements.

The microLED chips themselves could also be transfer printed. Here, an elastomeric stamp could pick up these chips, stamping and thus transferring them at high speed and yield onto the final target substrate. There are currently many firms developing a variety of transfer printing techniques for this purpose, although the competition from other approaches including laser-based ones is very stiff.

Finally – and possibly most promising – is to achieve colour conversion via printed quantum dots. A major challenge holding microLEDs back is the need to transfer millions of microLEDs with practically zero defects. To transfer all three colours would be extra complicated. Thus, one could transfer only the blue microLEDs and achieve red and green colours with QD colour conversion.

A technical challenge is that microLEDs are too small for inkjet printing (ca. 40µm print resolution), and their size is bound to shrink further to improve display resolutions and economies of scale. To address this need, EHD (Electrohydrodynamic Printing) is being

used, demonstrating lab printing resolutions of 1-10µm with likely mid-term reliable print resolutions around 15µm, translating to some 1000 dpi. The EHD printing still needs to be further developed and scaled, especially to a multi-head high-resolution technique without loss of print resolution, stability, or speed. Of course, EHD is not the only way to achieve QD colour conversion, but it is still very much in the running for manufacturing selection with strong chances vs. the photoresist-etch option.

Passive Electronic Components – printing components in the trillion range

MLCC (Multilayer Ceramic Capacitors) are literally on every electronic board. This is a market in the trillion-unit range. MLCCs are also a fast-growing market with the increase in demand supported by the trends towards 5G and mmWave, vehicle electrification, as well as ADAS and autonomous driving. All these trends increase the MLCC content per device substantially.

MLCC consists of hundreds of layers of printed Ni electrodes on special ultrathin dielectric layers. The outside electrodes are also made with conductive pastes (often via dipping). Interestingly, MLCCs are printed with screen printing being the dominant method of production, especially in the automotive segment, followed by gravure printing. Thus, R2R printing is the manufacturing method of choice for one of the most prevalent and omnipresent passive components of the electronic industry!

Interestingly, this market is not only impressive in terms of production volume but also in terms of technical achievements. The thickness of the dried layers is in the sub-micron range with no pinholes and high uniformity. Indeed, the trend towards achieving ever thinner capacitors – together with a higher dielectric constant and a higher number of stacks - is what has allowed surface mountable MLCC capacitors to reach such high area capacitance values.

Electronic manufacturing – from interconnects to 3D PCBs

Additive manufacturing is already commonplace in electronic manufacturing. Indeed, solder paste is almost always additively deposited with stencil printing being the technology of choice followed by jetting/dispensing. In stencil printing, the speed of printing is around 100-155mm/s with type-4 solder pastes (20-30 µm particles). The common linewidth is around 160-170µm linewidth with 0.4 to 0.5mm pitch.

In the PCB industry, inkjet printing is also gaining a foothold. Indeed, inkjet printing solder masks is already a commercial process with automated machines [for example: the inkjet printer can handle 610x610mm² substrates with automated feeding/inspection and 9 or more print heads].

Here, digital additive deposition of solder masks enables shortening of the process flow and the turnaround time compared to etching. Furthermore, the process is greener or more sustainable, since it is additive, wasting less materials and energy. The stronger green credentials are a market adoption driver that is growing in importance as OEMs seek to make their value chains - from materials to manufacturing - more sustainable.

Printing will become even more prominent in the industry. Companies are already deploying inkjet printing in manufacturing two-layer flexible PCBs. Here, for example, the inkjet printing deposits a thin conductive seed layer with high adhesion to PET (not PI) which is then thickened with copper plating to achieve bulk conductivity and solderability. A major driver of adoption here is the trend of making the process more sustainable, reducing material waste as well as water and toxic chemical consumption.





To see, feel, and touch the growing successes and the wonderful diversity of this industry, TechBlick is hosting “The Future of Electronics RESHAPED” events in Boston (12 & 13 June 2024) and Berlin (23 & 24 October 2024) where the entire global industry can learn and connect.

More info on www.TechBlick.com

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Semiconductor packaging – from wire bond replacement to package-level EMI shielding

Semiconductor packaging is one of the most innovative frontiers in the electronics industry. The complexity of packaging is always increasing with more systems in a package, with more packaging layers and dimensions, and with ever smaller feature sizes. Vacuum and subtractive processes (e.g., photolithography + etch) are the main technologies of choice in this size domain, which is beyond what printing can typically achieve today.

So how can additive electronics play a part? There are many potential use cases where it could deliver value such as selective package-level EMI shielding. Here, the idea is to replace vacuum PVD processes and masks with site-selective non-vacuum digital deposition techniques such as spraying, inkjet printing, or aerosol printing of some type of conductive ink. In this sector, the value proposition is clear, but dislodging a reliable and proven existing process benefiting from the momentum of incumbency remains a challenge. In this market, the adoption by a single major OEM is likely needed to break open the market gates.

In the packaging field, there are many other potential use cases. For example, digital non-conformal and non-contact printing could be used to form interconnects between chips and the substrate or board, eliminating traditional wire bonds. The advantage here is that the interconnect path would be shortened, and the wire bond loop and the associated inductance eliminated, enhancing high-frequency performance despite the lower conductivity of printed materials vs. wire bonds.

Human-machine interfaces (HMIs) and InMould Electronics

Printed HMIs are also already everywhere today (e.g., membrane switches or touch inputs on many white goods, industrial machines, etc). They are the bread and butter of most printing houses today worldwide. But faced with shrinking margins and ever-higher commoditization, many companies are seeking to diversify. InMould Electronics (IME) offers a viable opportunity. The idea here is to print functional and graphical layers onto a flat sheet(s), integrate ICs and lighting elements as needed, and then thermoform into a 3D shape followed by moulding. Of course, traditional screen printers must learn to pick and place ICs as well as to thermoform, but they can then offer unique HMIs with structurally integrated electronic and lighting features, enabling novel non-flat and 3D designs and saving weight, space, and manufacturing steps.

IME has been in development for some decades with some false dawns. However, the convergence of several business, technical and manufacturing improvements can unlock the market: (1) several companies are installing the entire toolchain needed to manufacture IME products, meaning that the value chain will be simpler to manage and the process easier to master, (2) accumulated pilot manufacturing experience will likely lead to improved production yield, which is critical because a defect in the final stage of manufacturing means throwing away the entire device with integrated high-value electronics since repair of embedded part is not possible, and (3) businesses are model are showing more pragmatism, lowering legal/IP barriers to the use of protected technologies. It is a realistic hope to think that these trends will combine to finally bring a wave of IME products to the market.

Printed sensors

Printed sensors are one of the most successful areas of printed electronics. The established examples are glucose test stripes, which are printed in the billions. Printed biosensors are growing in complexity, evolving towards multi-layer structures with rapid precision multi-layer screen printing.

Printed sensors are also a core element of many wearable devices including various ECGs, incontinence sensors, etc. In fact, wearable sensors are another growth market for printed electronics, particularly since the strengths of current commercial screen printing on flexible substrates match well with device requirements in terms of production speed, cost, line width requirements, precision, yield, etc. This alignment means that current production assets can be utilised to serve the market without requiring further long-term technology developments.

Printed sensors are even present in the exacting automotive business, showing that the printed electronics industry can manufacture and deliver even to the auto industry. Many occupancy sensors in cars are screen-printed. This market is fast growing, as some legislators now demand that back seats are also equipped with occupancy sensors. Other sensors included in cars are touch sensors, made based on printed metal mesh films, integrated into driving wheels or other parts to replace mechanical switches. There are many other examples, showing that the automotive industry is a major customer and user of the printed electronics industry. In most such cases, the industry is at a mass manufacturing scale.



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New international media hub for converting and flexible electronics has been launched

On the final page of PRO Flextronics, we will look beyond technology and business, focusing on the people behind the tech – and their stories. In our PREMIERE, we would like to introduce ourselves: We are PRO Flextronics. We are M2N Media GmbH.

M2N Media GmbH officially started its business operations at the beginning of 2024. The company, which was jointly founded by Managing Partners Martin Hirschmann, Nina Pirchmoser and Nadine Bauernfeind, offers competent, up-to-date and independently researched specialist information for the global coating and web processing industry as well as the growth sector for flexible and printed electronics.

Multichannel B2B communication

The three founders pursue a holistic approach that aims to combine the best of all worlds: Print, online, live events and other digital formats complement each other to create a perfect multichannel mix for contemporary B2B communication. In addition to the regularly published print magazines PRO Converting (editions in German and English) and PRO Flextronics (in English), M2N Media GmbH's offering also includes a versatile and

highly attractive website with daily industry news for both branches of industry served by the media company. The digital offering includes monthly newsletters, podcasts, online talks and video content, compiled live at the most important industry events.

Journalistic principles

"We founders have been active in the sectors we serve for many years and know the opportunities and challenges, but also the special structures in these industries," says Martin Hirschmann, Managing Director and Editor-in-Chief. "Even more important, however, are our long-term personal contacts, which are characterised by mutual trust and which we want to continue to cultivate and expand in order to offer the industry the optimum media portfolio for its activities. We always act according to journalistic principles and are not afraid to take a critical view. One important focus is on the topic of sustainability, which is a burning issue for many decision-makers in our industries – as both an opportunity and a challenge!"


Ideal environment for advertising and advertorials

"For machine and system manufacturers, as well as equipment suppliers in the coating and web processing industry as well as in flexible and printed electronics, we offer the perfect environment for a wide range of advertising and advertorial formats," says Nina Pirchmoser, Managing Director and Head of Sales at M2N Media GmbH. "We look forward to getting in touch with you directly to bundle your comprehensive advertising and content packages!"

Modern layout, adaptive website, multi-channel presence

"We are focusing on a modern appearance in our print media, with the optimal digital extension as an e-paper, as well as a website that meets all our requirements – and it also has a great design!" emphasises Nadine Bauernfeind, Managing Director and Head of Design.



Image source: 
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Your PRO Flextronics team:
Nadine Bauernfeind,
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