

Printed and Hybrid Electronics: Mounting Applications and Technology Breakthroughs

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Rodman Publishing

Printed Electronics *NOW*

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inkworldmagazine.com





Launched in 1995, Ink World is the only global magazine, web site and weekly eNewsletter for the ink industry.



Printed Electronics *NOW*

Launched in 2008, Printed Electronics Now is a website, weekly eNewsletter and digital magazine devoted to the fast growing field of electronic products created through the printing processes.



Today's Agenda



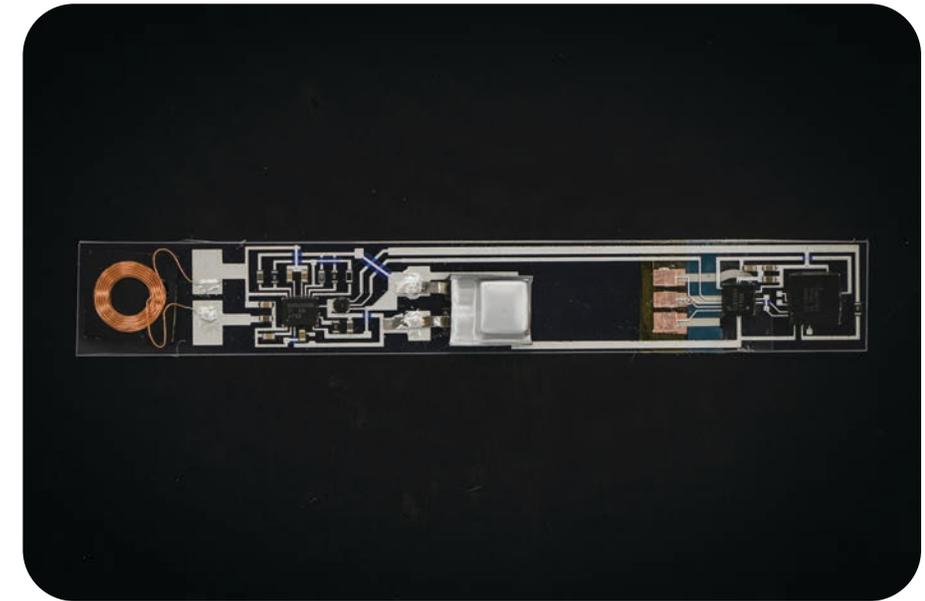
- What are Flexible and Printed Electronics
- What are Conductive Inks, and What is Their Role
- Where We are Seeing Flexible and Printed Electronics
- What Does the Future Hold for Conductive Inks and Flexible and Printed Electronics



What are Printed Electronics?

Printed electronics is the use of printing to deposit conductive and/or functional materials on various substrates, including paper, plastic, metal, films and others.

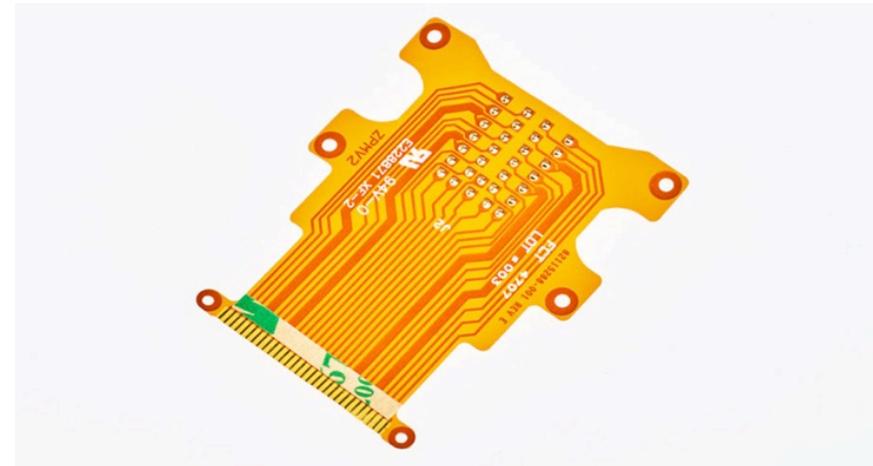
- Printing processes include screen and inkjet printing, with work being done on flexo, gravure among others.
- But printing isn't the only way to produce these materials – slot die coating, aerosol jet, 3D printing among others.



What are the Key Advantages of Printed Electronics?

- These systems can be mass produced at low cost.
 - This would be necessary for the IoT and item-level tagging.
- They can be flexible and conformable – ideal for wearables.
- They have been around a while – membrane switches, printed circuit boards.

Hence, the idea of flexible electronics.



Early Successes for Printed Electronics

- Glucose Test Strips for Diabetes
- Printed Heaters for Cars
- RFID for Pallets - WalMart
- eReaders
- These were primarily screenprinted, which offer the advantage of thick coatings, which improves conductivity.



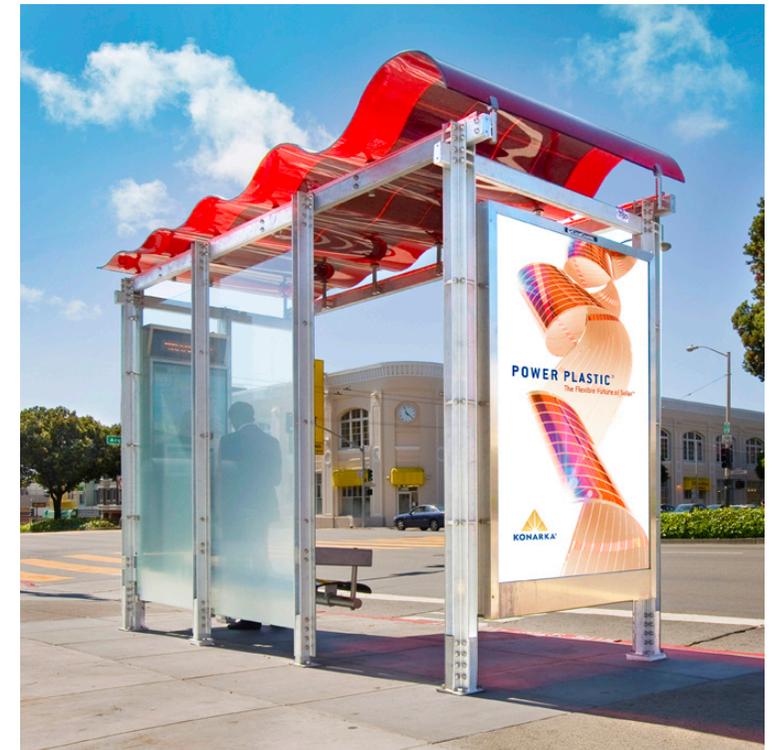
But Printed Electronics Did Not Take Off As Expected

- Initial projections were way too optimistic (\$300 billion a year by the 2020s)
- Many products were short-run novelties
 - Lighted boxes to catch the eye, toys
- Photovoltaics, eReaders never took off for a variety of reasons.



Reasons for Printed Electronics' Initial Problems

- Manufacturing was not ready to meet potential demand.
 - There was plenty of money available, but not much was being produced.
- Results could not be translated from lab to fab.



Initial Disappointments for Printed Electronics – Organic Photovoltaics

- Konarka and Nanosolar each received way more than \$100 million in funding.
- OPV companies burned through millions in cash without making a product.
 - Konarka bought old Polaroid plant in New Bedford, MA
- Three percent efficiency wasn't going to cut it.
 - Lab results could not be marched in production

OPV still has potential although it is moving slowly.



Initial Disappointments for Printed Electronics – eReaders

- E Ink led initial wave, working on the Kindle
- However, other eReaders couldn't reach production
- Black and white eReaders couldn't match an iPad's draw
- E Ink and Plastic Logic just introduced its first flexible color displays in late 2020.



The Rise of Hybrid Electronics

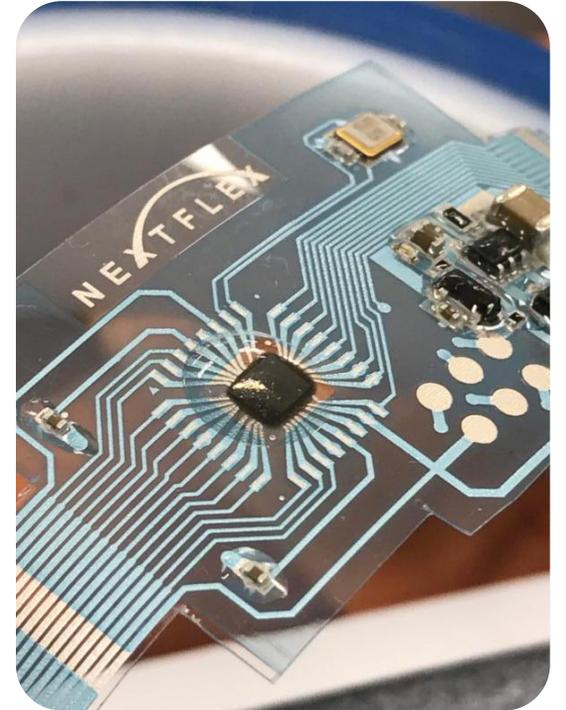


- Printed electronic systems couldn't meet performance and production needs.
- The infrastructure of printers wasn't in place.
- However, hybrid systems, combining silicon and printing technologies, can meet these needs:
 - Silicon chips have performance benefits.
 - Jabil, Flex are billion-dollar companies with vast manufacturing expertise in semiconductors.
- NextFlex is bringing flexible electronics and manufacturing together.

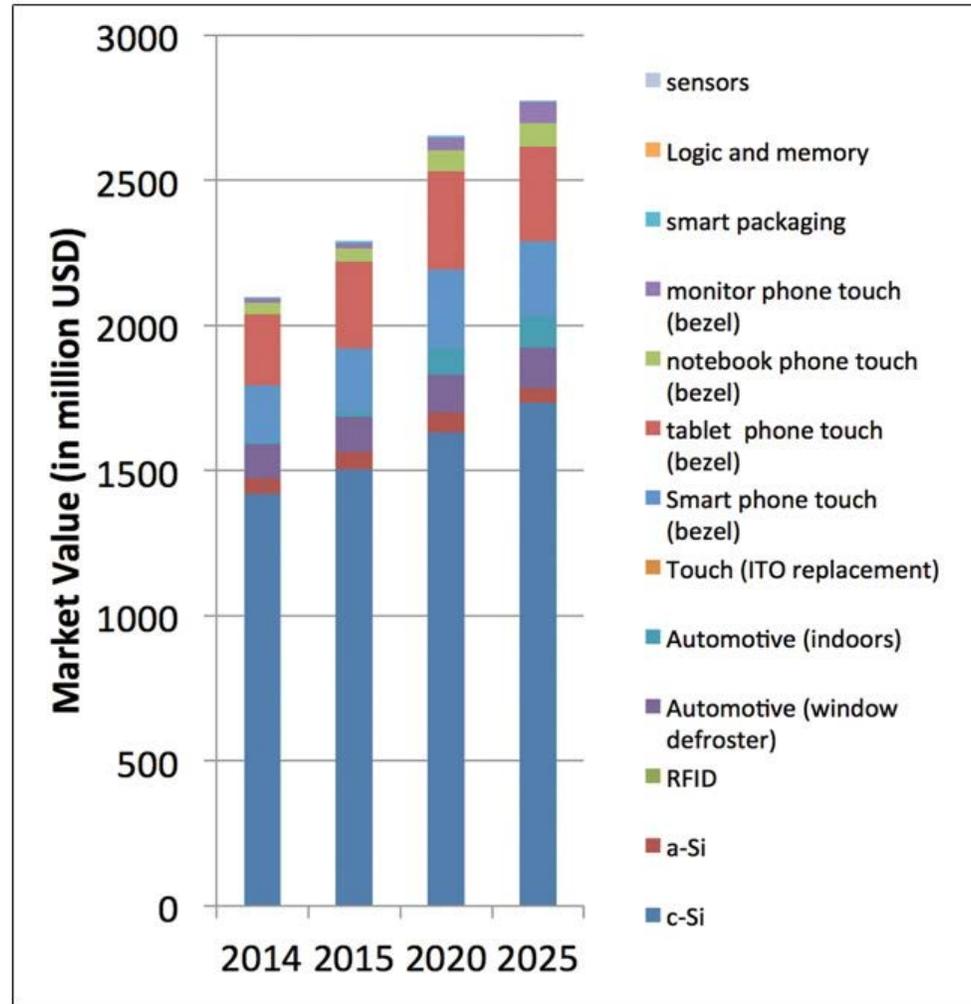


A Few Words on Conductive Inks

- Conductive ink is an ink that results in a printed substrate being able to conduct electricity.
- Primarily, we see silver- and carbon-based materials being used.
- Other materials are being examined, such as copper-based inks, although there are challenges such as oxidation.



THE MARKET FOR CONDUCTIVE INKS

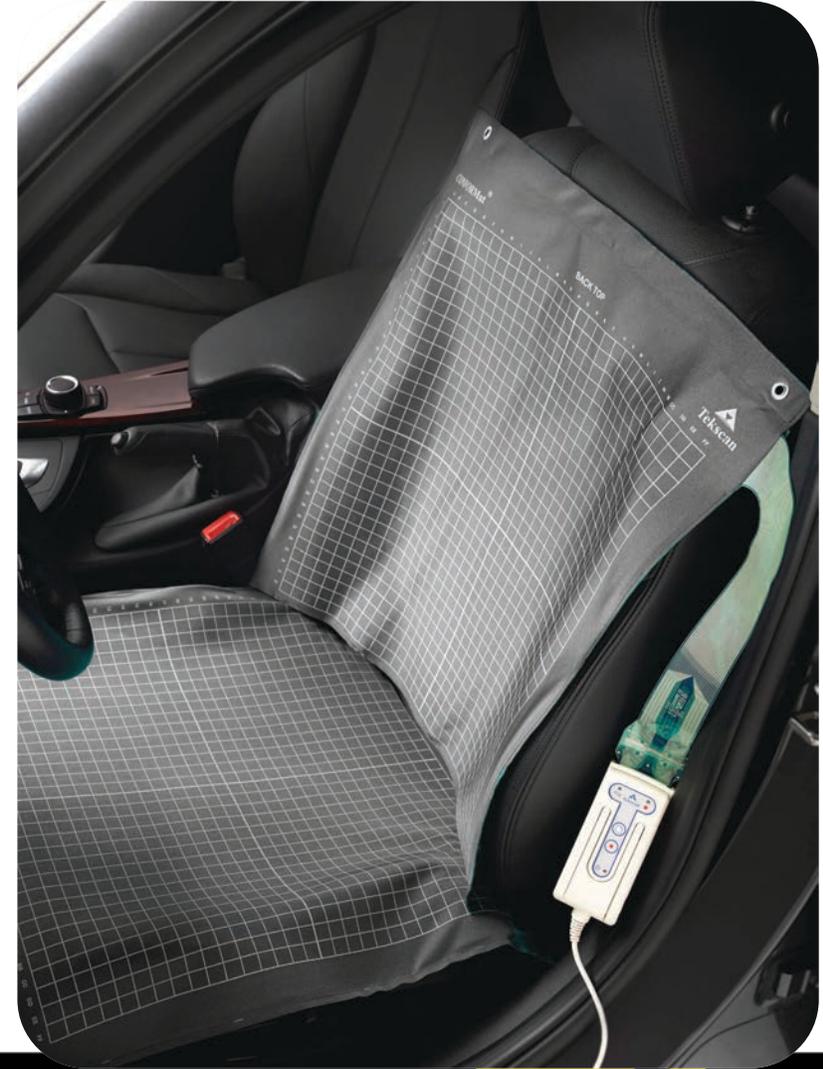


Courtesy of IDTechEx



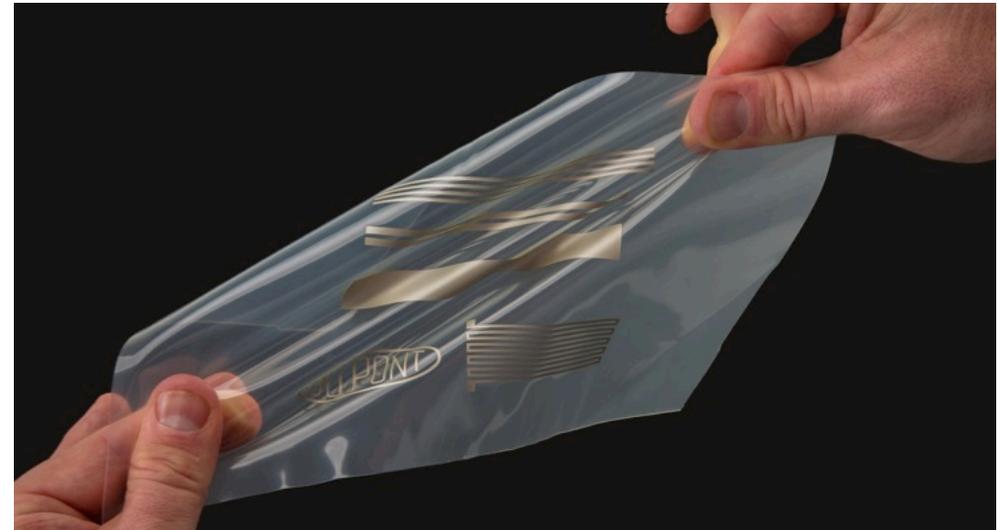
Present Markets for Conductive Inks

- Photovoltaics – Conductive inks are screenprinted on the backplane – it is the major use of conductive inks
- Displays and Tablets – Bezels
- Automotive market – Printed heaters, airbag and seat belt sensors



Major Players in the Conductive Ink Field

- There are large corporations as well as successful start-up companies in this space:
 - Sun Chemical
 - NovaCentrix
 - DuPont
 - Henkel
 - Heraeus Precious Metals



Shakeups in the Conductive Ink Industry

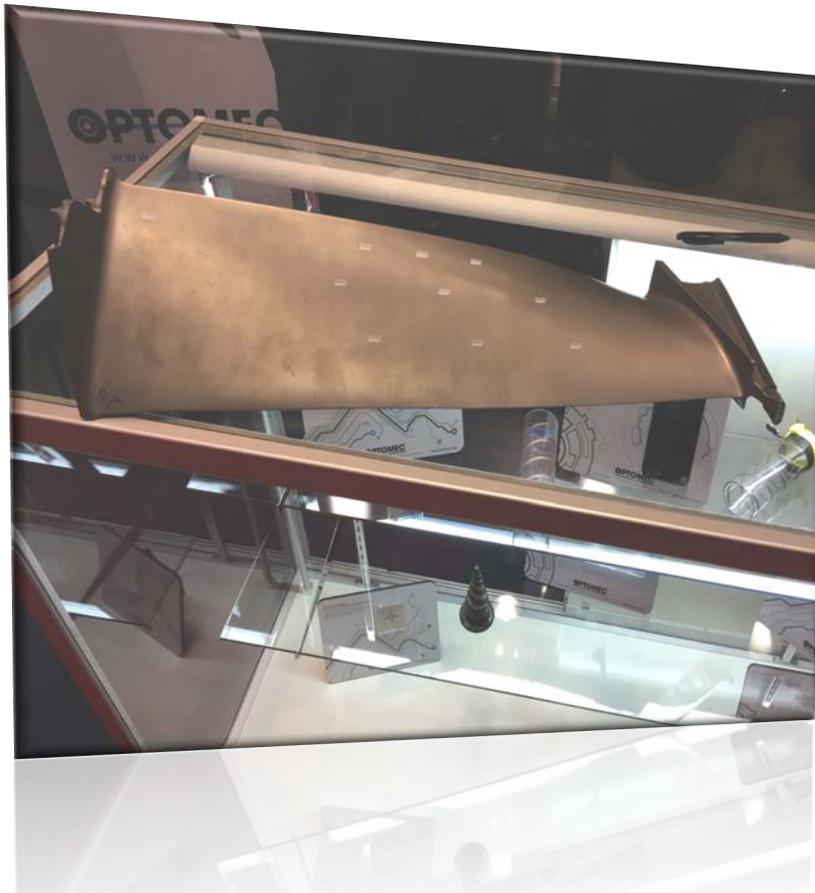
- Much like the smaller start-ups in the printed electronics field, there have been innovative companies that have fallen to the side or been acquired over the years.
- The technology may have been there, but the market and/or production wasn't ready yet.
 - Plextronics
 - Intrinsic (acquired by NovaCentrix)
 - Gwent (acquired by Sun Chemical)



Where are We Seeing Flexible and Printed Electronics



From automotive to healthcare and much more, flexible and printed electronics are making their mark.



Automotive

- Hybrid OLED-LED lighting is starting to appear in luxury models.
- Audi A8, BMW are using OLED lighting.
- Printed heaters have long been a staple for printed electronics – DuPont, Henkel
- In-mold electronics are being developed to simplify electrical systems and reduce weight



In-Mold Electronics

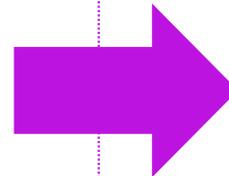
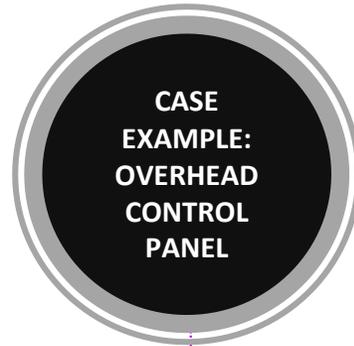
- This is a terrific opportunity for the automotive market.
- They are screenprinted and thermoformed.



IMSE for Design Innovation, Reduced Complexity

Conventional Electronics

- 64 parts + PCBA
- Costly assembly
- 45mm assembly depth
- 650 grams



IMSE—Seamless smart molded structure

- 1 molded part + small PCBA
 - Fewer parts to design, less tooling, less inventory, minimal assembly
- 3mm molded material thickness, 90% less
- 150 grams, 70% less
- TCO 25% less
- 35% greenhouse gas reduction

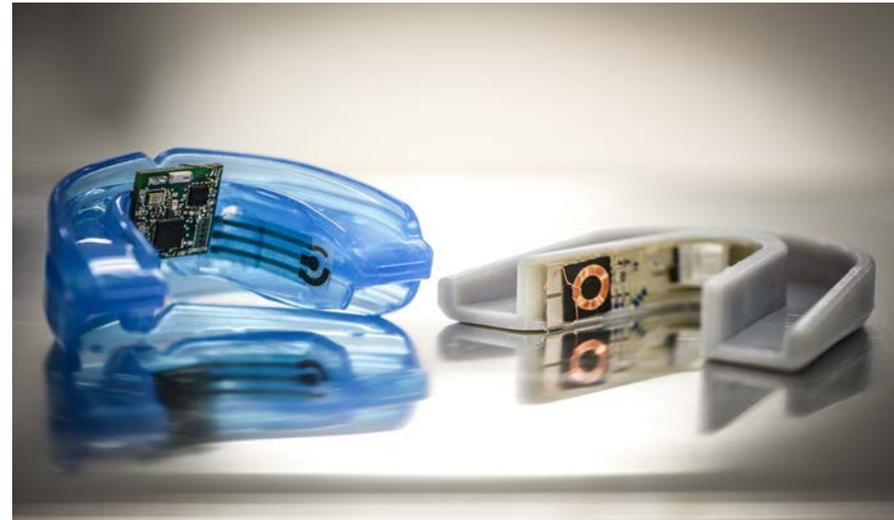
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Healthcare

- Glucose testers have long been printed
- Sensors monitor health characteristics such as diabetes, athletic performance



Healthcare



- Dental sensors
– Dr. Jean Bausch GmbH & Co. KG - OccluSense
- LED light patches – CareWear
- UV sensors – L'Oreal



Printing Dental Sensors

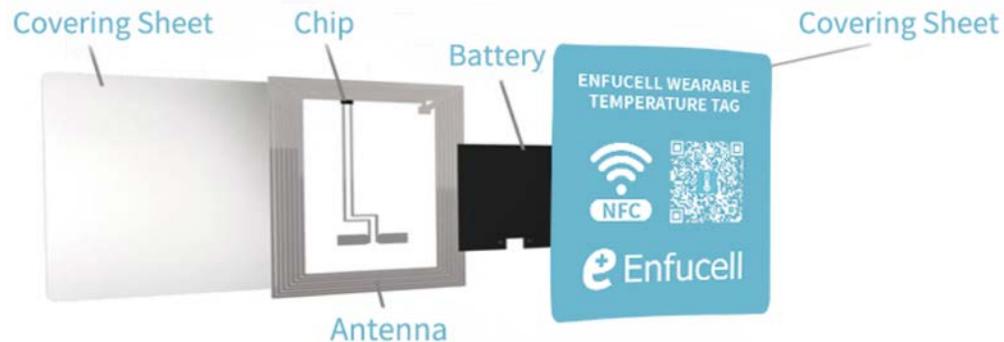
This is a terrific example of printed electronics.

- Jean Bausch GmbH, Heidelberg and InnovationLab have developed the system.
- Heidelberg is now printing electronics.



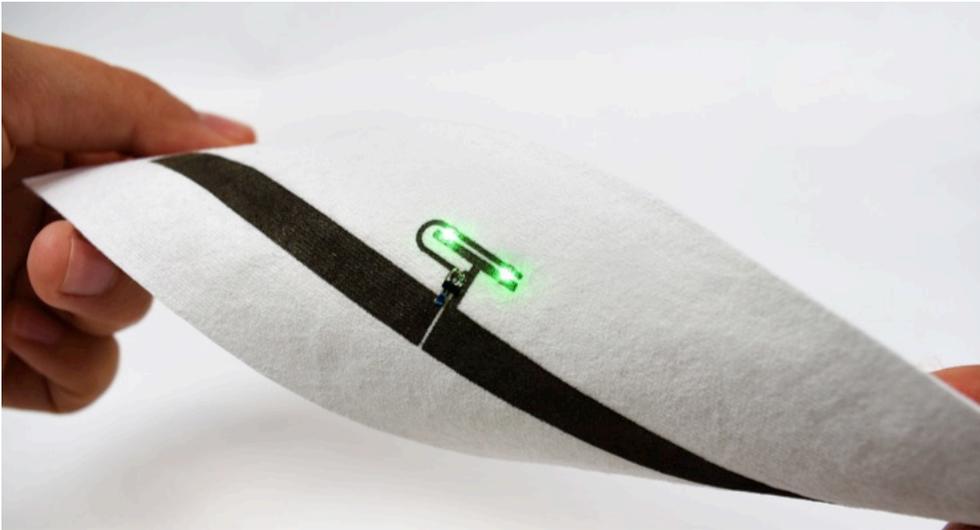
COVID-19 and Flexible and Printed Electronics

- Enfucell supplied wearable temperature tags using their printed batteries to hospitals in China.
- Identiv created its body temperature patch

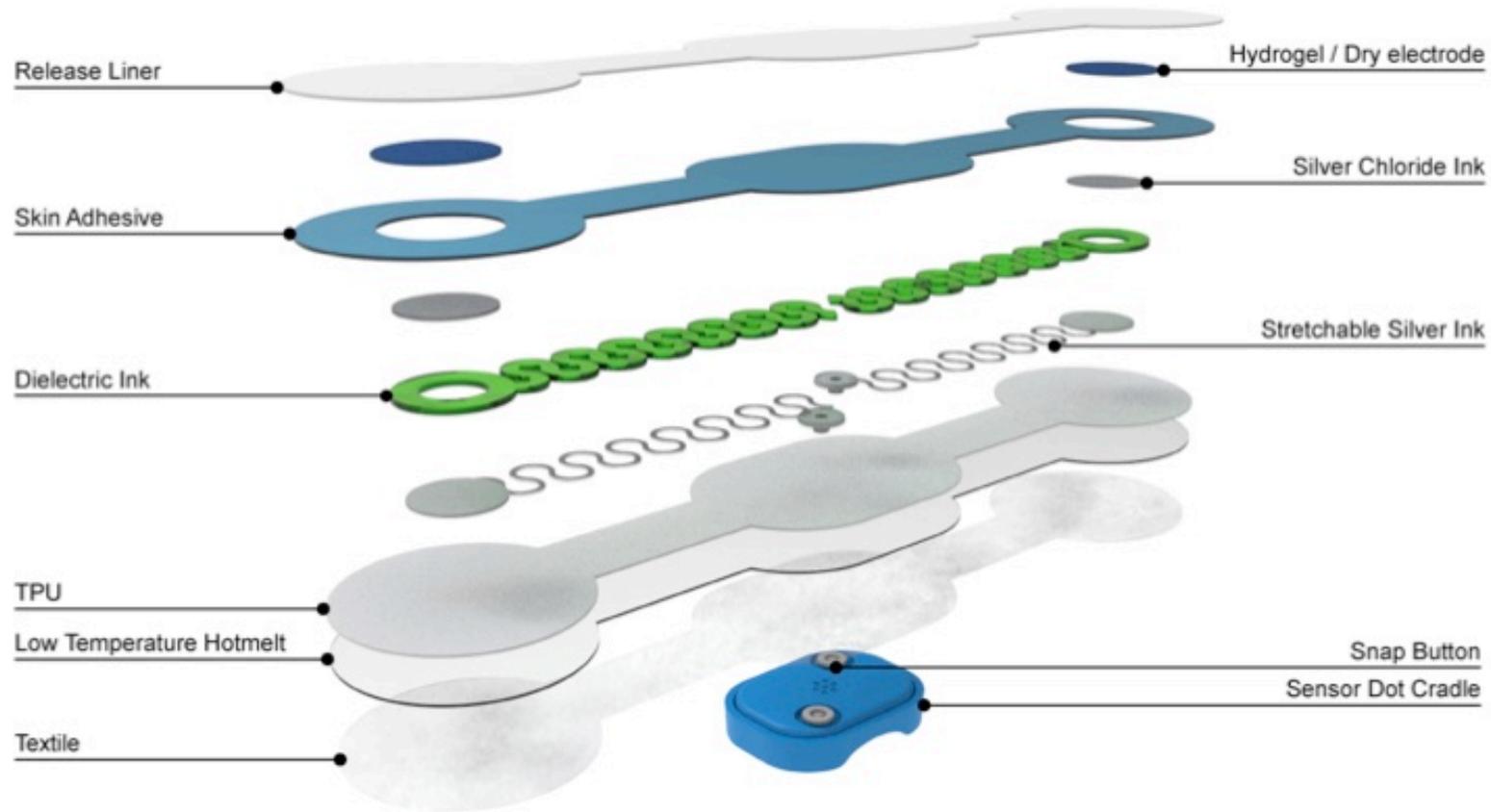


Performance Monitoring

- Wearables are designed to monitor athletic performance
- Olympics, NFL are among the groups utilizing the technology



This is a schematic of a collaboration of a smart running patch by Quad Industries, Henkel and Byteflies



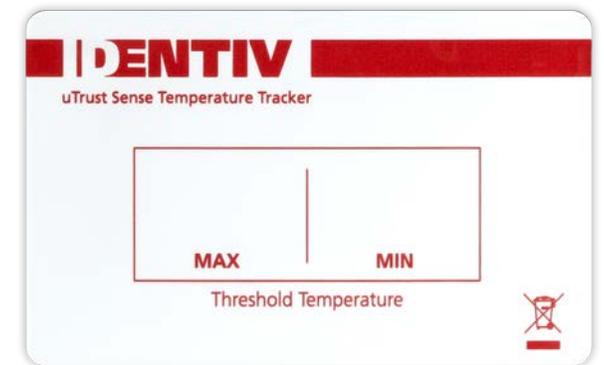
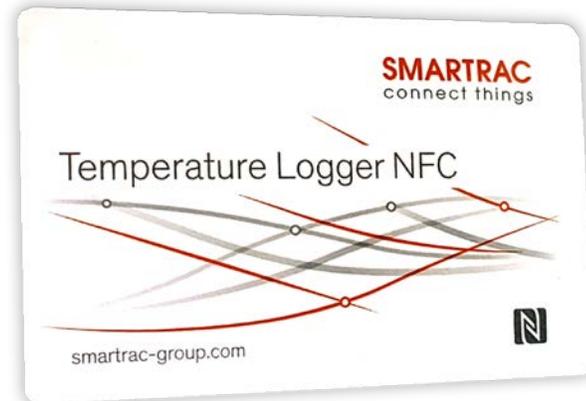
Flexible Electronics Today

- InviSense humidity sensors printed by Ynvisible.
- Imprint Energy's printed batteries.
- PolyIC touch screens in appliances.



Smart Packaging

- Temperature loggers
- A lot of interest in RFID and other systems to monitor food throughout the supply chain
- These can help eliminate massive waste and spoilage in medicines and perishables



Smart Packaging

- Connecting with customers
- adidas' World Cup soccer ball
- Mammut's sports jacket
- YUNI Beauty



Wearables as Clothing

- Ralph Lauren's heated Winter Olympics Jacket
- Lubrizol's conductive ink jacket

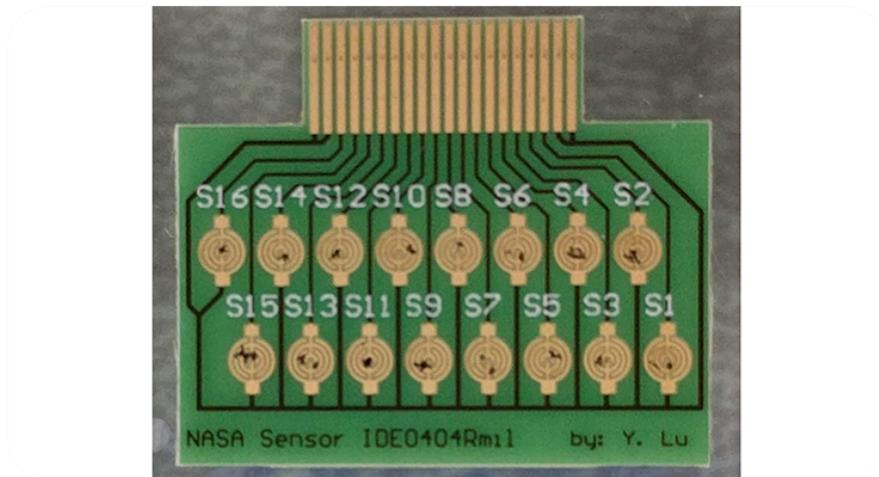


Schematic of the Ralph Lauren Jacket

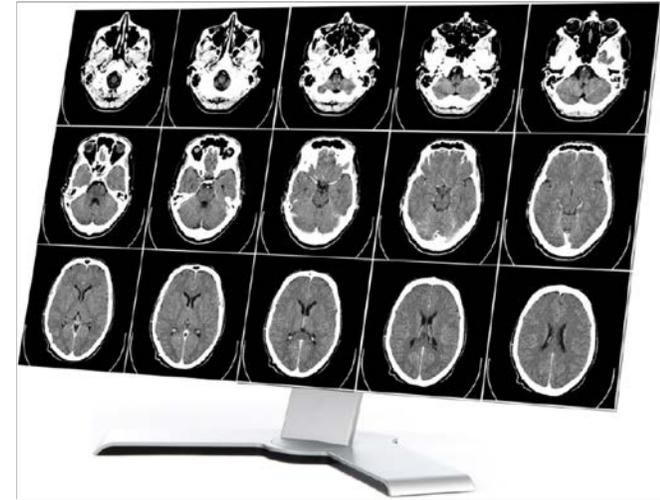


Military Applications

- NextFlex is a collaboration between the US Department of Defense and FlexTech Alliance (SEMI)
- SI2 – helmets
- NASA's gas sensors



Displays and Lighting



- OLEDs
 - OLEDs are approximately 30% of the smartphone market (Yole)
 - One billionth OLED smartphone display was shipped earlier this year – Samsung Galaxy S, some Apple models
- 2.5 million OLED TVs sold in 2018 – mostly high-end
 - LG Display dominates OLED TV market
- OLEDs are being inkjet printed
- Foldable and rollable displays



Quantum Dots

- Three to four million QD TVs sold in 2018
 - Samsung dominates QD TV market



- Ultimately, they can be inkjet printed
 - Nanosys and DIC are collaborating on inkjet printable quantum dots



OLED Lighting

- Automotive tail lights
- Lighting for home
 - Human-centric lighting
 - even, diffuse lighting



RFID and Retail

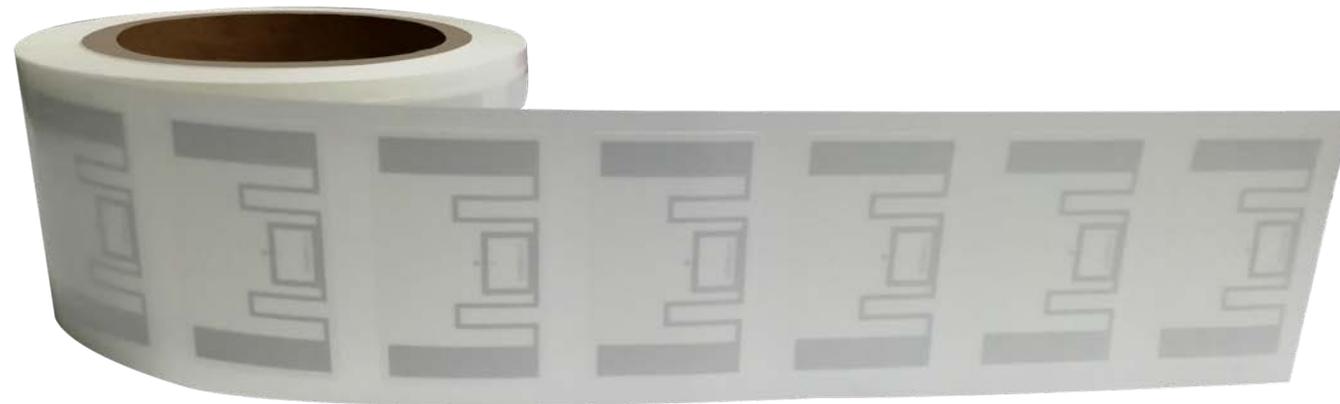


- Omnichannel shopping – order online and pick up
- Benefits include ability to have real-time insight into inventory, as well as what sells for brand owners and retailers and what the product offers for consumers.



RFID – Other Uses

- Luggage tags – more airports are starting to use RFID
- Tolls
- Smart cards and badges



The Future of Printed and Hybrid Electronics

There is every reason to expect flexible and printed electronics to continue to grow, and printers and ink manufacturers will play a significant role.



Thank You!

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