

Integrated printing technology for sustainable electronics

Printed electronics is a high-tech emerging industry that has the potential to transform many sectors, from healthcare to HMI, robotics, logistics and many more. However, not substantially enough efforts have been made yet for its widespread commercialisation. Saralon (Chemnitz, Germany) is known not just for innovation and developing new inks and application prototypes, but also for ensuring their successful penetration into the market.

The advantages of printed electronics are twofold: sustainability and scalability. Conventional methods of manufacturing electronics involve corrosive and harmful chemicals, generate significant waste, and larger amount of energy. In contrast, printed electronics offer the possibility of using non-toxic materials, reducing waste through resource efficiency and making it a much more sustainable alternative. Integrated additive printing is the solution that addresses both sustainability and scalability. By using additive printing, manufacturers deposit electronic materials on a single piece of substrate in precise patterns layer-by-layer, reducing waste and improving material efficiency. This process also eliminates the need for toxic chemicals, making it a more environmentally friendly option. Furthermore, this approach allows for flexibility in design, enabling customised solutions for specific applications.

However, the diffusion of high-tech electronics innovations into low and medium-tech printing houses presents another challenge. Saralon has taken on this challenge by providing not only high-quality inks for printed electronics but also the know-hows to printing houses. This strategy allows for the seamless integration of their inks into existing production processes, reducing the cost and the risk associated with adopting a new technology. This approach accelerates the commercialisation of printed electronics and drives sustainable innovation in the industry. Considering the challenges and opportunities in printed electronics, here Saralon introduces SaralBattery Inks and advanced expertise in the integrated printing which smoothen its commercialisation efforts. These ink solutions

plus production know-hows (InkTech) are bridging the gap between traditional printing and high-tech electronics.

Introducing SaralBattery Inks

Conventional lithium-ion batteries have excellent performance parameters, but they are inflexible and flammable, and therefore pose a risk to the environment. The advancement of electronics into almost everyday life, the spirit for miniaturisation of smart objects and the search for environmentally friendly solutions have led to the emergence of thin-film and printed batteries. These batteries offer a flexible and reliable solution for powering portable electronics, making them ideal for integration into smart gadgets and wearables.



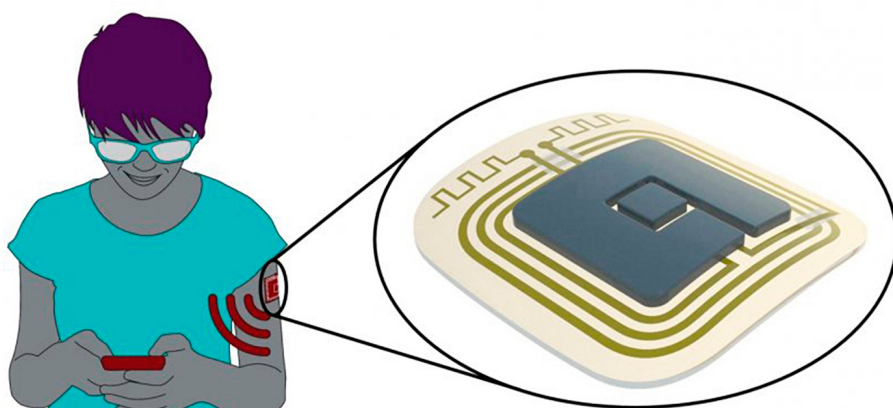
[Fig. 1]: Self-powered blood test cards developed within IMPETUS project using SaralBattery Inks in an integrated printing process (Source: IMPETUS project)

Printed batteries are made of multi-layer non-toxic materials that offer a high level of safety, making them an appealing option for health-related applications.

Having production scalability, design flexibility and technology affordability in mind, SaralBattery Inks were developed to easily customise and screen-print batteries on lightweight recyclable substrates as an integrated part of the whole electronic circuit. Unlike ready-to-use printed batteries on plastic substrates, which are available in the market, these inks are printable on biodegradable material such as paper, to manufacture sustainable batteries.

SaralBattery Inks is a set of seven inks that could be printed in series connection to increase voltage to meet the required energy quantities, reducing unnecessary costs and allowing for customised solutions. A key specification to this ink set is the presence of uniquely designed ink between the anode and the cathode that eliminates the need for a separated process of paper placement. This printed layer is electronically insulating but ionically conducting. Designed for low voltage applications, this ink set is the perfect choice for sensor technology applications, providing a self-sustained, and easily integrated power source.

Now that worldwide competition is on to develop new smart objects, Saralon works alongside with printing companies and electronic device manufacturers to identify prospecting markets and enables them to produce the most appropriate battery by optimising its parameters such as geometry, electrochemical performance, or the choice of substrate material, depending on the application requirements in a 100% integrated printing process.



[Fig. 2]: Integration of a printed battery using SaralBattery Inks on flexible ELSAH medical patches (Source: ELSAH project)

In the following sections, we look into some innovative applications of SaralBattery Inks in practice.

Disposable and wearable medical patches

A highly promising market for the printed electronics industry is the smart medical sector that fulfils the need for fast and inexpensive diagnosis at the point of care and adequate treatment. The potential of printed batteries extends to such medical technology applications where the safety of energy storage devices is critical. Here we briefly review two use cases of SaralBattery Inks in the medical sector.

Within IMPETUS project, SaralBattery Inks were used to develop self-powered biosensing blood test cards for identifying viral and bacterial infection. These disposable diagnostic test cards enable direct data transmission to the user's smartphone via RFID communication that eliminates the need for extra apps.

Key advantages of SaralBattery Inks technology over the commercially available batteries for this project include the possibility to be printed on paper as a biodegradable material that is both human and environmentally friendly and also the integration of all battery layers in the continuous flow of printing process. The latter allows for the establishment of a pilot industrial line which combines printing and electronics in a seamless roll-to-roll process that is capable of mass production and offers the possibility of adoption for different healthcare and food sensing applications.

Another development project in the medical sector using SaralBattery Inks is called ELSAH project in which the power source was printed as an integrated part of a wearable sensor system for molecular biomarker concentrations

monitoring. These smart medical patches collect bio data via minimal invasive micro-needle base sampling from dermal interstitial fluid (ISF) that is proven to be very similar to the blood biomarker data. Using printed batteries made of SaralBattery Inks in combination with microchip and antenna connecting structure allowed for fully self-sustaining and independent functioning of the product.

Fully printed temperature loggers for cold chain data transparency

Cold supply chain is a complex ecosystem with multiple stakeholders and data visibility technology plays a crucial role in making all engaged parties from the beginning to the end responsible for accountability and consumer trust. Hence, data loggers are used to monitor product integrity and ensure compliance with regulatory expectations across the cold supply chain.

Development of printed temperature loggers is in progress at Saralon using 13 specialised inks and in particular, innovative SaralBattery Inks. Compared with conventional electronic loggers, their ink technology opens up great opportunities for the printing industry by creating very thin and flexible loggers at very reasonable cost that consistently and easily track the temperature of pharmaceutical and food products as they travel through the whole cold chain.

Developing such innovative solutions to address the limitations of conventional practices, is a challenging task of printed electronic designers. Such complex approaches should be able to integrate display, battery, SMDs and data communication features on

a lightweight substrate in an additive printing process.

The production process of temperature loggers by Saralon is a 100% integrated screen-printing technology, that combines:

- Printed battery (using SaralBattery Inks)
- Printed display (using SaralElectrochromic Display Inks)
- Printed NFC (using a High Solid Content Silver Ink)
- And attached SMDs (using screen-printable Saral Conductive Adhesive Inks)



[Fig. 3]: Development of fully printed temperature logger using Saral Inks

Layer by layer integration of these specialised inks result in the development of sustainable loggers that allow reliable data monitoring, identifying and mitigating the risks and ultimately ensuring the product integrity during the whole supply chain.

Joint effort is the key

The connecting road from technological innovation to the market is not an easy, straightforward one. Successful commercialisation of printed electronics requires a collaborative effort between high-tech and low- & medium-tech industries. This means careful consideration of value creation and delivery mechanisms to effectively diffuse the technology to the conventional printing companies. In doing so, production know-how transfer is a key element of Saralon's company strategy. This model works great in empowering conventional printing houses in the ever-increasing market competition.

Image sources: IMPETUS, ELSAH, Saralon