Flexible batteries for tomorrow's applications

The growth of wearable technology and the increased use of medical electronics devices is intensifying demand for ever smaller and thinner batteries and energy harvesting devices. We spoke to **Dr Robert Hahn** about the Matflexend project's work in investigating new materials and developing flexible, rechargeable batteries well suited to emerging applications

The development of wearable electronic devices has generated a great deal of interest, with companies and research institutions exploring potential applications in navigation, healthcare monitoring, communication and many other areas. A reliable supply of energy is of course essential to the effective operation of these devices, an area that forms the primary research focus for the Matflexend project, an EC-backed initiative developing thin, flexible and rechargeable batteries. "We're developing low-cost production technologies, to make relatively small batteries and energy harvesters," says Dr Robert Hahn, the project's Principal Investigator. These batteries are designed to be applied in wearable technology. "We have developed a concept of very small, segmented batteries, as we now have the technology to make a lot of small batteries in parallel," explains Dr Hahn. "We have made them to be relatively stiff, but in several segments interconnected on a flexible substrate, and then there is a degree of flexibility between the segments of the battery."

Project consortium

The project overall combined both fundamental and applied research, from material development to the eventual fabrication of prototype batteries and energy converters. Czech company Pardam nanotechnology, one of the ten partners in the project, used forcespinning to fabricate nano fibers for both batteries and capacitive harvesters; besides being a very innovative and low-cost method, Dr Hahn says this approach also leads to several other benefits. "With fibres, you get better interconnectivity of the material and mechanical flexibility. Another important point is that this can also be used to produce fibres for the separator," he explains. While polymer foils can be used as separators in larger batteries, a new approach is required for small batteries. "You cannot put a small foil inside each battery when making very small batteries, so you have to apply printing processes. It's also important that the material can be fabricated and printed. The silicon oxide fibres from Pardam are well-suited to this," continues Dr Hahn.

As a team leader at the Fraunhofer Institute in Berlin, Dr Hahn is involved more in the applied side of the project's work, and developing functional prototypes of micro-batteries and energy harvesters. The aim in terms of the latter is to utilise energy harvested from the environment to charge small electrical devices. "We're looking at energy harvesting and storage on a very small scale, for applications like micro systems, sensors and portable devices," outlines Dr Hahn. These applications do not typically need large amounts of energy, so efficiency is less important than in larger applications, yet Dr Hahn says it remains a consideration. "For small applications, the most important point is that you have this certain amount of energy that is required for the application, regardless of the efficiency. On the other hand, the higher the efficiency the better, as you can make the device smaller and increase the power density," he points out. "The efficiency can be increased if the mechanical deformation energy of the harvester electrodes and package is as small as possible."

This needs to be balanced with the need to maintain a high level of flexibility in the batteries, in line with the demands likely to be placed upon them when used in applications like wearable technology and

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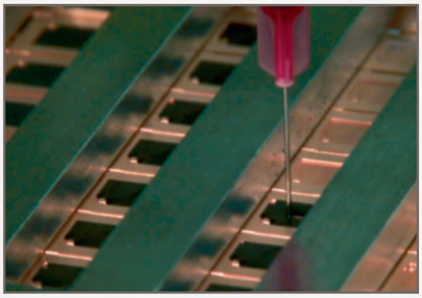
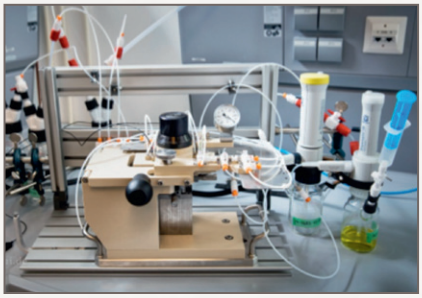
Argon box prototyping line for substrate integrated lithium micro batteries.



Dispense-print of battery electrodes.



Apparatus for simulataneous electrolyte filling in segmented batteries.

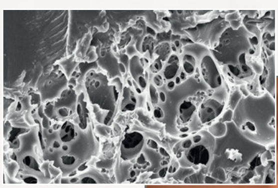
medical devices. Another important consideration is the need to package these batteries very tightly to prevent the leakage of electrolytes. “It’s not easy to make flexible batteries, because they need to be packaged very tightly. Otherwise there’s a risk of what can be extremely harmful effects, even fire,” warns Dr Hahn. The batteries are packed inside an argon container, preventing oxygen and water permeation; this helps ensure the batteries’ suitability for use in medical electronics, where safety is paramount. Fraunhofer IZM invested more than 1 Million Euro in 2016 for a battery prototyping line dedicated to the electrolyte filling and hermetic sealing of the micro batteries.

This is a field in which Dr Hahn says there is a high level of demand for micro batteries. “Today, very small medical sensors are being used in medicine, and they need ever smaller and thinner batteries,” he outlines. “If the battery has to be very thin, then it may be necessary to use printing technology or other means like electrophoretic deposition that was also developed in the project,. In addition a microfluidic device was developed that allows simultaneous electrolyte filling into hundreds of micro batteries which are fabricated in parallel on the same substrate.”

Medical electronics

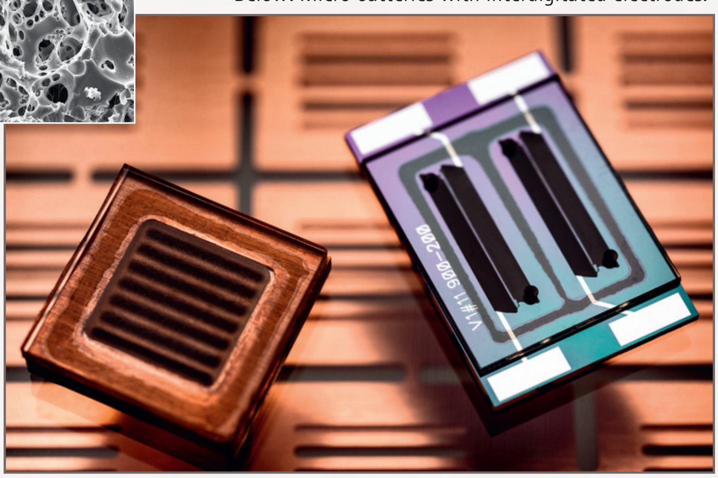
There are a wide range of potential applications for these batteries, particularly in the medical electronics field, which researchers intend to explore in future. With the Matflexend project having officially concluded in September, Dr Hahn plans to pursue further, more application-oriented research in future; one major area of interest is miniaturized hearing aids. “We have another German-funded project, for a very small hearing aid called EarLens, which is directly mounted on the eardrum inside the ear. The device has a diameter of only 6 mms and a height of only 2 mms,” he outlines. Researchers aim to develop a 700 µAh battery, giving 12 hours of autonomous operation, providing the kind of long-term stability that is highly important in terms of the eventual use of the EarLens. “Our very small, rechargeable battery will be used in the EarLens, and it can be recharged using a photo-diode and an infrared LED,” says Dr Hahn.

We are also working in a new project with a major mobile phone producer; here segmented rechargeable batteries are integrated into the wristband for smart watches and sensor bracelets.



Above: PolyHipe porous polymer for battery separator and harester electrodes.

Below: Micro batteries with interdigitated electrodes.



At a glance

Full Project Title

MATerials for FLEXible ENergy harvesting Devices (MATFLEXEND)

Project Objectives

MATFLEXEND investigates new materials for energy harvesting that are flexible, durable as well as solution-processable into printable inks, and which therefore enable mass-producible energy harvesters which integrate mechanical-to-electrical energy conversion and storage in a single device. Basic research in developing new materials and formulations will thus be complemented by testing them for printability, so as to enable mass fabrication of such harvesters in a printing process.

Applications include smart textiles such as garments or insoles, as well as other essentially planar devices, such as e.g. a smart card, or an autonomous electrochemical sensor applied to a surface.

Project Funding

MATFLEXEND is co-funded by the European Commission.

Project Partners

Fraunhofer IZM • Imperial College • Univ. Vienna • eurecat • SMARTEX • LAAS – CNRS • VARTA • Anitra UG • Pardam • Comcard

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Dr Robert Hahn

Dr Robert Hahn received his Ph.D degree in electrical engineering in 1990. Since 1995 he has been with the Fraunhofer-Institute for Reliability and Microintegration (Fraunhofer-IZM) where he is head of the portable power supply group. He has taken over the coordination of several national and European research projects for the development of new micro-batteries, micro-fuel cells and integrated power supplies for micro systems and portable electronics. Dr Hahn has authored and co-authored numerous papers in the fields of microelectronics packaging and micro energy systems as well as 30 patents in the area of micro energy systems. He received the f-cell award for the Fraunhofer micro fuel cell development in 2005.