Sensing solutions for intelligent packaging supporting circular economy and IoT

VTT Technical Research Centre of Finland presents an ultra-thin smart data logger label demonstrator for item level temperature monitoring

Packaging has an important function in the protection of products during the transportation throughout the distribution chain and hence in contributing to sustainability by minimising product losses, in particular in regard to food waste. The adoption of new technologies for connected products in the packaging sector enables value-added intelligent packaging that can communicate information about the product to manufacturers, marketers, and consumers, and store data on a connected platform for further use and analysis.

Intelligent packaging technologies provide means for controlling packed product quality, provide more convenience to consumers, market and brand the products, and control counterfeiting and theft. Intelligent packaging emphasises the ability to sense or measure and further communicate an attribute of the packaged product, the atmosphere inside the package, or the environment. Suitable technologies include sensors, indicators, barcodes and RFID (Radio Frequency Identification). These technologies combined with printing based manufacturing processes enable the connectivity of packed products and packages to the Internet of Things (IoT).

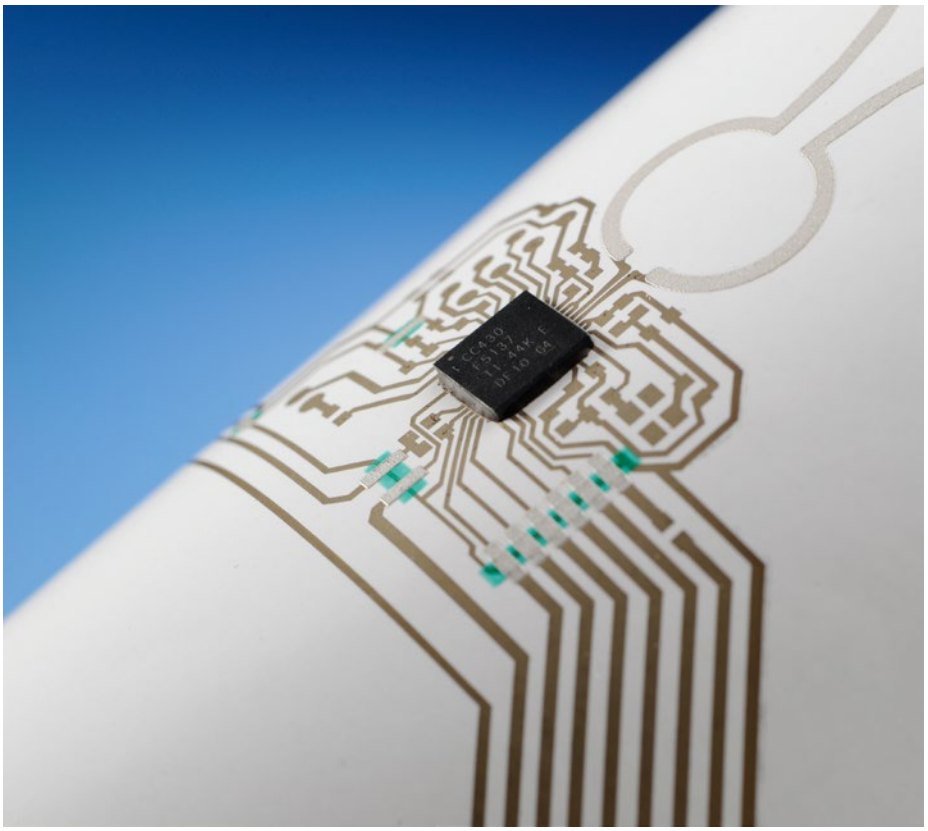

Figure 1: Electronic components printed and assembled on paper substrate: details from a smart envelope demonstrator developed in the EU FP7 Ropas project [3]

Sustainable and intelligent components

Circular economy is an important aspect when developing electronics based intelligent packaging solutions, since packages typically are recyclable or decomposing items. The materials used for the intelligent components have to be sustainable i.e. compostable, recyclable, even biodegradable, so that the intelligent packaging supports the circular economy, and not interfers with existing waste management and recycling processes. The European Union highlights in its recent report that the global consumption of material resources has increased fourteen-fold between 1900 and 2015, and is projected to more than double between 2015 and 2050 [1]. In addition, the EU Ecodesign directive aims to reduce energy and resource consumption by promoting the better environmental performance of products [2]. This accounts for the utilisation of renewable material resources, such as cellulose or other biomaterial based substrates, and also for printed electronics. Due to digitalisation the need for sustainable materials spans also outside the intelligent packaging sector. It is expected that in several applications electronics will be preferably embedded or released to the biological environment at some point of their lifecycle, such as soil, crop or weather monitoring, or disposable health monitoring devices.

Modern electronics are filled with circuit boards on which various metals and plastics are soldered together. Some of these materials are toxic or break down into toxic substances. Electronics made of paper or of other sustainable materials (cellulose based materials, bioplastics, biocomposites) are viewed as a potentially cost-effective alternative in various applications (Figure 1). Use of these often flexible and foldable materials enables the use of roll-to-roll high-speed printing that is considered a more material-efficient process (less material waste during manufacturing) than traditional electronics manufacturing methods. One of the most promising areas for paper (and other bio-based materials) electronics and photonics appears to be intelligent packaging.

Figure 2: A smart data logger label demonstrator (T-tag9, developed by VTT)

T-tag in logistics

VTT has developed an ultra-thin smart datalogger label demonstrator (T-tag) for item level temperature monitoring purposes in logistics via Android application as user interface (Figure 2). The T-tag is based on an extremely thin (h= 40µm) NFC temperature monitoring IC for logging and communication and indicator LEDs (h < 200µm) for indication of logging and threshold temperature. The circuit has been screen-printed on a paper substrate and the logger is powered by two flexible batteries (1.5V, 10mAh, h ~ 500µm) with 6 years theoretical shelf-life in stand-by mode. This type of logger can be used to track the temperature of the packaged item from the labelling even up to the consumption and hence to boost sustainable and safe transport and storage of temperature sensitive products. To support the sustainability goals VTT has initiated the Finnish national ecosystem project ECOtronics where sustainable electronics and optics solutions are developed with intelligent packaging as one target application. This joint effort between the Finnish research community and industry develops highly recyclable and compostable materials for printed electronics and optics, promotes environmentally friendly manufacturing technologies (e.g. printing, overmoulding) to reduce the use of materials, develops the methodology to recover the materials, and quantifies the environmental impact of the developed solutions.

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References:

[1] European Union reflection paper. Towards a Sustainable Europe by 2030. January 2019.

[2] https://ec.europa.eu/growth/industry/sustainability/ecodesign_en

[3] http://www.ropas-project.eu/

Image sources: VTT