HORIZON 2020

Printed Intelligent NFC Game cards and packaging

Reporting

Project Information

PING

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Project website

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Project closed

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€ 3 334 243,00

Coordinated by
CARTAMUNDI TURNHOUT
Belgium

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Periodic Reporting for period 2 - PING (Printed Intelligent NFC Game cards and packaging)

Reporting period: 2016-07-01 to 2017-12-31

Summary of the context and overall objectives of the project

The emerging technology breakthrough of the Internet-of-Things is expected to offer promising solutions for packaging and interactive entertainment. The PING project anticipates on this evolution and aims to develop flexible metal-oxide Radio-Frequency Identification (RFID) tags seamlessly embedded in folded carton packaging and game cards. This will introduce RFID technology at lower cost and without changes to product dimensions and mechanical characteristics. Moreover, one-time programmable memory (PROM) will enable additional functionality. The objectives of the PING project are:

• Development of a Process Design Kit (PDK) for automated design of complex integrated circuits
• Advancing the design of complex RFID circuitry with enhanced performance and functionality using the developed PDK
• Implementation of scalable manufacturing processes to realize flexible, metal-oxide RFID circuitry
• Evaluation of suitable antenna manufacturing processes and chip bonding technologies
• Demonstration of flexible, fully integrated metal-oxide RFID tags in the existing products of two end-users scalable to high-volume markets

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

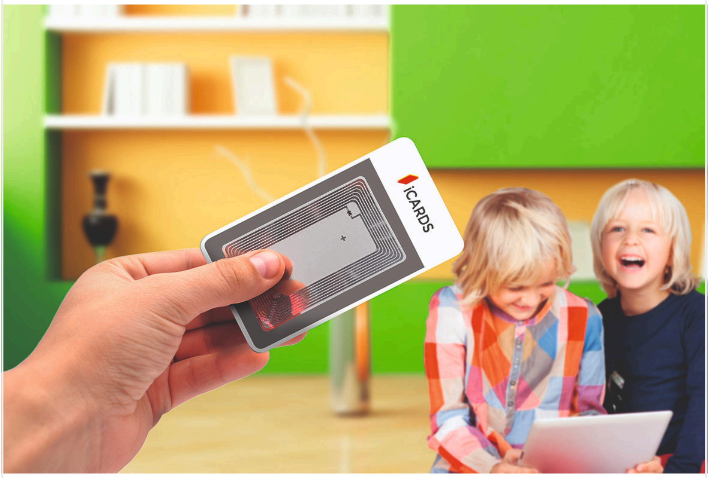
We successfully developed a design platform, realized RFID building blocks, antenna printing technology, memory processes, singulation, chip bonding technology and product integration.
At first, application, system and technology specifications were defined, whereby 5 priority use cases were defined focusing on the market needs and exploitation of CM and VGP. Towards the end of the project, with the additional knowledge gathered, the 5 uses cases passed the assessment on economical, safety and environmental feasibility.

A 'Process Design Kit' based on PP’s metal-oxide TFT technology was successfully created. Device models and a Design Rule Check file were developed and iteratively improved during the project. This PDK was used for design of mask-sets, including digital test blocks as well as analog building blocks, and ultimately for the final demonstrators.
A series of mask sets were fabricated in PragmatIC’s pilot production line and tested over the course of the project. Successful circuit designs have been realized included functional RF and digital logic building blocks, fully functional PING12 RFID circuits and prototypes of 128-bit RFID ICs including direct clock conversion from the carrier signal.
Manufacture of the 128-bit circuitry proved to be a low yield process given the realities of the pilot line. Nevertheless, validation of the underlying design and technology functionality was achieved, providing confidence in the viability of higher expected yields with the dedicated production line.
Different memory process technologies as well as different memory design variations have been evaluated. The focus changed from single bit PROM memory elements to 128-bit PROM arrays and unprecedented 1kbit PROM arrays with NFC compatible clock speeds in year 3. Laser ablation has been selected as the preferred approach to program the memory.
Printed antennas were designed and realized with additional effort on evaluating conductive inks and certified papers. A comparison of additive technologies with etching and laser cut technologies has demonstrated the benefit of printed antennas within PING. Performance, environmental and reliability tests have been performed with satisfying results. Automated roll to roll screen printing was used to show a feasible mass production process.
Many technical options for dicing and foil release has been explored, preferred methods have been identified. For the chip to antenna bonding, the flip-chip process using ICA, was the best method identified by SMT. Pick and place trials on a high-volume assembly line were performed. With respect to the chosen standards and test procedures the lifetime and reliability testing was proved to be feasible.
CM and VGP developed and tested the processes and test equipment to integrate RFID tags into paper cards and packaging. The compatibility with the existing mass manufacturing systems and the required similarities with traditional cards and packaging was successful. Both companies started their go to market activities to acquire interest in the market.
A project website (http://www.pingproject.eu) has been set up during the first month of the PING project to provide information on the project to the general public.
PING has been selected as winner of the Innovation Product Award at EFECS 2017, recognizing that the PING project paves the way for trillions of interactive objects that will expand the Internet of Things to the mass market.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

The concept of integrating an electronic layer between pre-printed paper layers is new in the industry of paper cards and boxes. The potential impact in the printing industry is huge. It merges all the possibilities of different printing techniques with electronics, without interfering with the core manufacturing processes. This means large quantities, very small quantities, unique products,

specialty printed products can be foreseen with RFID inside, in a cost effective way since the inlay gets inside late in the process, avoiding expensive electronics got wasted during print make-readies.
We are still in an early stage with respect to the integration of the electronics inside the finished products, tests have been proven feasibility of embedding thin film electronics inside pre-printed paper layers. Achieved thickness, stiffness, look and feel, materials are beyond state of the art.
With respect to circuitry, a state-of-the-art PDK for TFT logic on plastic foil and a state-of-the-art metal-oxide RFID chips on flexible film have been realized. The published chip advances state-of-the-art in power x delay, as the obtained state-of-the-art data rates are 5.5x improved compared to previous publications while maintaining similar power figures. The data rates are proven to be compatible to all NFC standards which is a big advancement in the field of metal-oxide RFID tags. A large achievement of this work is the demonstration of a fully integrated 12-bit RFID transponder chip with an on-paper printed antenna.
In case of laser programmable read-only memory (LPROM), major progress has been achieved within the PING project. We have demonstrated simple 12bit LPROM blocks and increased the density up to 8 kilobit LPROM memory, which is truly state-of-the-art. In addition, the read-out speed has proven to be compatible with the ISO NFC standards, with reading speeds above 106 kbit/s. The 1024 bit memory available in a flexible NFC tag paves the way to realize NFC Forum Type 1 and type 2 tags, supporting even NDEF messages, the only NFC communication possible to iPhones. This will pave the way for other use cases beyond the PING project.
The PING flexIC provides improvements with regard to the state of the art. The chip has a thickness ~10 µm including substrate, all functional layers, and passivation, whereas the currently available silicon chips have an average thickness around 75µm. The flexibility of the chip supports the mechanical characteristics like bending properties of a playing card.
First additive antenna structures printed on paper and initial test runs to integrated inlays between two paper sheets were successfully demonstrated. Using silver inks including nanoparticles, low-cost manufacturing of printed antenna structures has been enabled. This provides potential new applications which have not been feasible to date.



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