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Blink Link

Marcel Grooten, CEO of DoMicro BV (Eindhoven, The Netherlands), discusses 3D structures with integrated electronic functionalities using inkjet printing technology

Meet 'Blink Link': a unique way to connect with friends and family over a long distance. To explore the potential of multi-material 3D printing and integrated electronics, touch sensitive wireless IoT objects for different ages were combined in a cloud-based application. DoMicro developed a foldable LED ball for children with flexible hybrid electronics on paper.

The demonstrator 'Blink Link' is developed within the work package Integrated Electronics of the Fieldlab Multi-material 3D Printing (MultiM3D): a research platform in an open consortium. It demonstrates manufacturing technologies of 3D structures with integrated electronic functionalities. The cloud-based application consists of a paper LED ball for children, a bracelet for adults and a 3D avatar for seniors based on the looks of a user. With one touch, the objects light up in the sender's colour. The coloured light signals provide a surprising way to let loved ones know 'in a blink' that you think of them, no matter how far apart you are.

Design freedom, customisation, human connection and interface

The global industrial additive manufacturing market is growing due to the increasing need for designing and manufacturing products directly from customer specific requirements. When choices in process and material are unlimited and ICT is intertwined with production technology, opportunities arise. Smart combinations of technologies and materials lead to unique multi-material product features, new products, new services, new market segments and business models. The Fieldlab was initiated to enhance the knowledge on this subject and the collaboration structure in the South of the Netherlands.

Blink Link combines 3D printing and application of printed electronics, assembly and interconnection of components. The objects all have LED lighting, touch sensor and connectivity functions. They demonstrate the benefits of design freedom and customisation, enabled by flexibility of integrated electronics. Focus is on end user benefits and interaction rather than on functional lighting aspects. Functionalities are integrated in various ways (flexible design and processing) and can be adapted to the end user's needs (e.g. for a wearable, 3D portrait, hand held device).

Functional electronic design and printing process for LED ball

DoMicro's core competence is in developing flexible hybrid electronics by inkjet technology and micro assembly. Typically, the fabrication process is 2D configured by nature. An example is the touch sensor demonstrator in fig. 2. For making this demonstrator, the electronic circuit including the three touch sensors was made with inkjet printing on a flexible substrate. Subsequently, the electronic components were bonded to the substrate. The ambition for DoMicro in the Blink Link project was to explore and extend the capabilities for making flexible hybrid electronics in 3D. Within the project, the DoMicro approach was to print electronics in 2D first, and then bend the electronics into the required 3D shape.

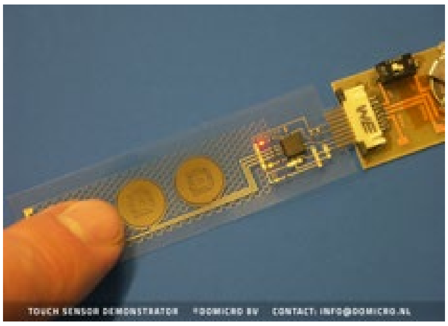

Fig. 2: Demonstrator with three touch sensors

Printing electronics on paper

A goal for the project was to investigate the feasibility of printing electronics on paper by ink jetting. More specifically, the processes for ink jetting and bonding on paper were studied in detail. In this work, the impact from stretching was a major parameter. Patterns made with ink jetting are not stretchable because the ink is based on nanoparticles. This is a major difference with screen printing, where the printed patterns are stretchable because the ink is based on micron sized Ag flakes.

The main focus concerning the printing was on jetting and dispensing of conductive ink. The work started with a conductivity test on three different types of paper from two different suppliers. On each paper, a test line with a size of 195 x 2.5mm was printed. The experiments revealed a wide range of resistances with a variation of two orders of magnitude. The paper with lowest resistance was selected for the realisation of the demonstrator.

In a next step, the processes for the thermal and the cleaning steps were studied. To meet the conductivity requirements, 4 to 5 layers were deposited on top of each other by inkjet printing. For the curing process the process window for the temperature (not too high

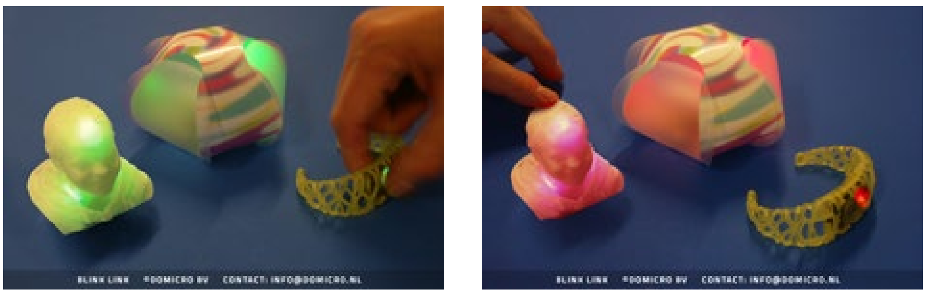

Fig. 1: Blink Link: touch sensitive wireless IoT avatar objects

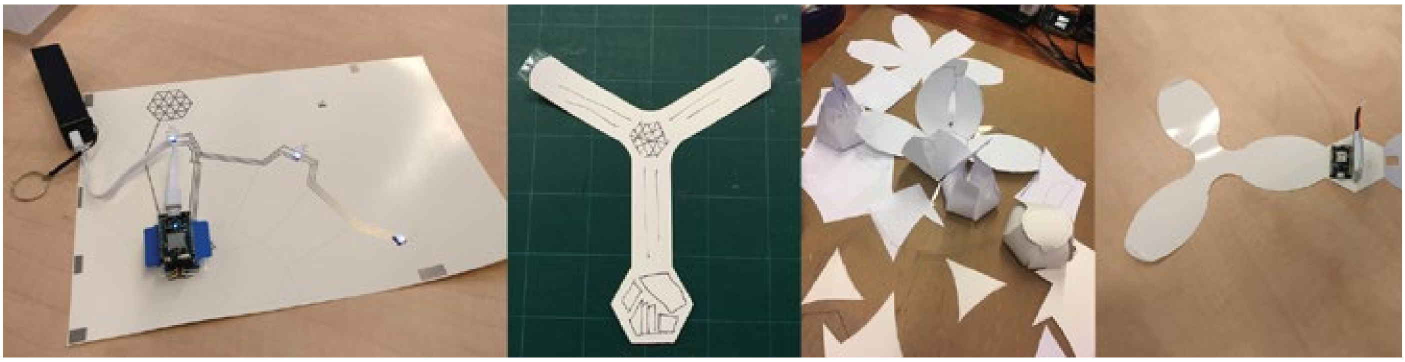

Fig. 3: Several steps from the design process

as this will affect the 3D printed materials) and time was investigated. Thermal curing (max 150°C) and IR curing showed good results and were used to build the prototypes. Printing multiple layers in different materials turned out to be feasible. This enables the printing of the so-called bridges, where conductive lines cross each other with an insulating layer in between.

From user needs to 2D design

The specifications for the LED ball were based on those for a typical indoor professional lighting product (10W input, 500-1000lm output) and on an exploration of user needs. Conclusion was that the needs are more in connectivity and interaction than in functional lighting properties. For example, it is important to have a multi-sensory experience with touch sensors for sending messages to other avatar users. The product specifications were translated into technology requirements such as track conductivity, interconnect resistance, track resolution, track width and height.
Based on these results, a 2D design for the paper with circuitry was made. This included a design for a capacitive touch sensor, conductive tracks and interconnects for the components. The shape of the paper was such that it can be folded into a ball shape. An appealing graphic design was made to cover the outer side of the paper which is visible for the end user.

From 2D design to a 3D LED ball

In the next step, the circuits were printed on paper. The components (LEDs and a small control board with a battery) were glued on the touch pads. A test of the functionality of the circuit was done. A second flat part was added: a transparent foil to complement the paper in a constructive solution for creating a robust structure with flexibility. Stickers with the graphical design were adhered to the outer side of the paper. Upon this step, the 2D semi-finished products were folded into the 3D ball shape.

Fig. 4: Flexible LED ball by folding 2D printed electronics on paper into a 3D shape

Fig. 5: Touch-sensitive LED ball for children by DoMicro

The final step was the integration of the LED ball in the Blink Link IoT network. This cloud-based network offered the IT infrastructure for coupling the products from the different partners in the MultiM3D consortium. Via this network, the DoMicro 3D LED ball can send and receive messages to and from selected other devices in the network. For the integration, with a set-up of the software on a cloud server the connection was established to the loved ones in Blink Link.

DoMicro BV is a technology company providing innovative manufacturing technology, application solutions and micro assembly technology for flexible hybrid electronics (FHE) and micro devices. DoMicro develops cutting edge inkjet printing processes and technology for micro assembly and 3D packaging. At the forefront of innovation DoMicro offers state-of-the-art R&D services and exploration of new capabilities and applications for customers with manufacturability in mind. The company delivers R&D services, small series production, system architecture and project management. Typically for customers exploring new technologies for circuitry on flexible substrates like transparent conductive films, OPV electrodes, OLED, Lab-on-chip, wearables, in-mould electronics, IC and MEMS integrations.

Image sources: DoMicro