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Wireless interface for wearable IoT devices based on inkjet-printing technology

To create a flexible IoT device as thin as possible, DoMicro (Eindhoven, The Netherlands) has developed specific inkjet printing technology and micro assembly techniques to integrate thinned bare dies on foils. Combining these technologies has resulted in a demonstrator for wireless IoT devices

Demand for integration of electronics and wireless applications such as Internet of Things (IoT), wearables, healthcare and sensors is increasing. Applications such as big data requires numerous sensors being integrated in tools, products, systems and even wearables for personal health monitoring and well-being. Sensor devices in those applications and products require seamless and invisible integration.

Die bonding and contacting

Several die contacting and bonding configurations have been studied by DoMicro. Figure 1 is showing a Fan In Ball Grid Array (BGA) configuration by inkjet printing on bare die. An inkjet-printed dielectric is covering the die keeping open areas at the contact pads. Next on top silver ink is connecting the bond pads to a BGA pattern on top of the dielectric coating. Alignment and registration of structures are performed through the automatic vision system of the used PixDRO LP50 laboratory printer equipment.

Figure 2 shows the flip chip bonding of a bare die to an inkjet-printed silver pattern. For interconnection high accuracy alignment die bonding equipment is used.

Figure 3 is showing the face up thinned bare die of a microprocessor being interconnected on the bond pads. As it is impossible to print conductive tracks via a steep vertical surface, a dedicated ramp structure is provided to guide and support the inkjet-printed silver conductors. This innovative approach of contacting is avoiding any regular and height consuming wire bond loops with glob top or as applied in advanced packaging, a redefinition layer or substrate (RDL) interface. This 'die first' approach is creating minimal height for assembly and mounting dies in systems. Special attention is given to the optical alignment and compatibility of material surface interaction. With this innovative technology a flexible hybrid electronic (FHE) demonstrator was built.

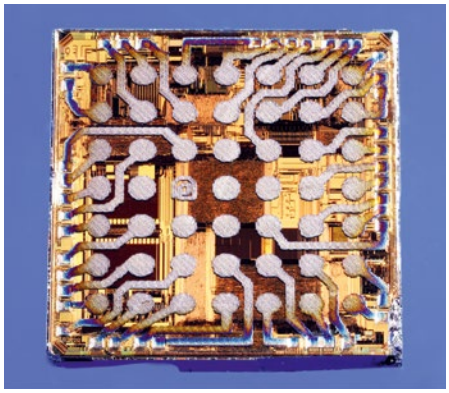

Fig. 1: Fan In Ball Grid Array printed on die

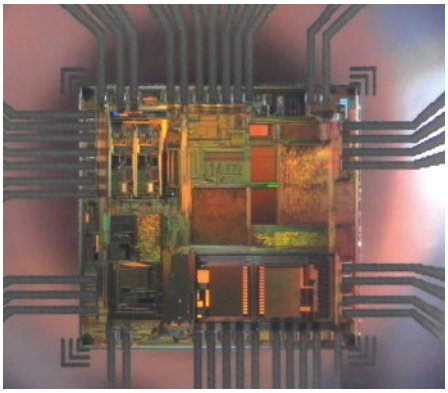

Fig. 2: Flip Chip bonding on printed tracks (through substrate view)

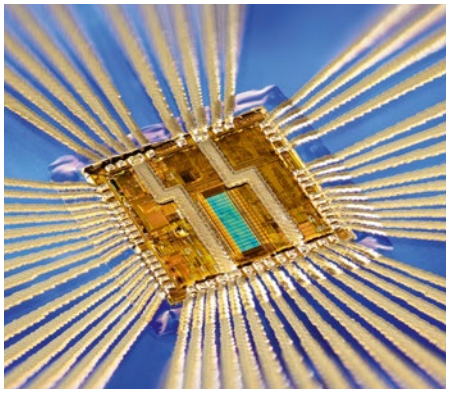

Fig. 3: Fan Out Die first face up

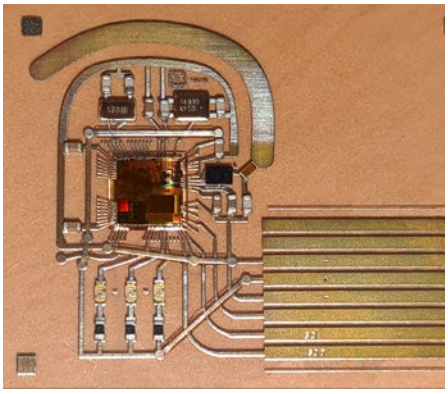

Fig. 4: Printed BLE beacon

Bluetooth beacon

The first step was to create the Bluetooth functionality. The Nordic 51822 Bluetooth low energy (BLE) chip was available in thinned bare die version and used. Based on an existing beacon design, a printed version has been built and demonstrated (figure 4).

Wireless flexible hybrid electronics interface

Typically, for having wireless functionality for IoT devices, some sensing function, computing processing and radio functionality should be combined and integrated to operate and communicate remotely from nodes to the network. DoMicro has built a demonstrator showing these functions by integration of a micro controller and Bluetooth radio Integrated Circuit (IC) onto a polyester foil. For the sake of demonstration, powering the demonstrator has been addressed with a regular cell battery. It is

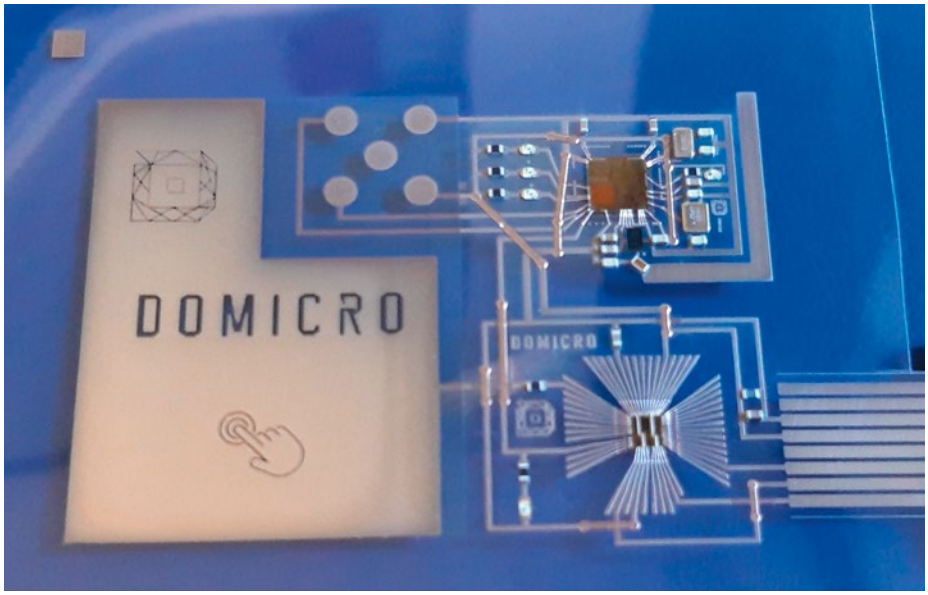

Fig. 5: Printed and bonded realisation in FHE

understandable that integration of a flat flexible battery solution would top off this wearable flat flexible device. Typical advantage over standard wire bond interconnection is the ability to print functional circuitry on all kinds of thin and bendable substrates. This form-factor enables smooth integration of functionality in all kinds of surfaces, labels, fabrics, etc. Next to that, the ability to integrate a bare die chip face up instead of flip chip, can expose the sensor interface in an extremely low height package solution.

On the polymer foil, a thinned Nordic 51822 BLE IC and a thinned Cypres CY8C20 touch controller are bonded and contacted in a functional circuit and antenna by inkjet printing technology. Powered with the external cell battery this demonstrator is able to show two-way Bluetooth communication with a cell phone app. The highly accurate inkjet-printed traces are aligned and connected to the fine pitch (60 micron track/gap) bond pad of the IC's. Passives used are approximately 0.5mm thick (height) as this is commonly available in SMD components. Figure 5 is showing the layout of touch area and electronic circuitry for both MC and BLE including the antenna structure.

After powering and testing by the Nordic Blinky app functionality is shown while interaction is initiated from the demonstrator device back and forth. The touch area is changing the states message in the app. Touch function is activated by a manual touch area on the sample, the state of the button is shown on the wireless interface. The LED can be switched on/off remotely and activated by a switch on the app.

DoMicro has demonstrated the possibilities of using FHE for thin bendable Bluetooth electronics that can be laminated in a thin flexible and/or wearable product or application. Target groups for the demonstrator can be all kinds of application developers in several industry sectors like automotive, transport and logistic companies, medical device companies, but also science, aerospace and other applications that might have a need for new ways of integrating electronic functionality in products and structures.

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 excels in developing 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. Its approach is lean, agile and dedicated.

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

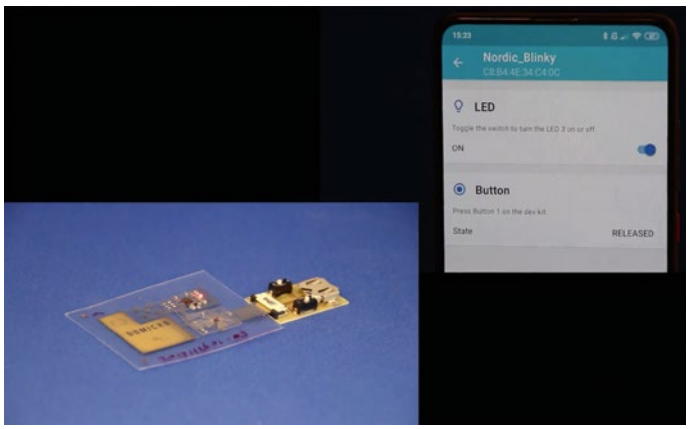

Fig. 6: LED on, button released

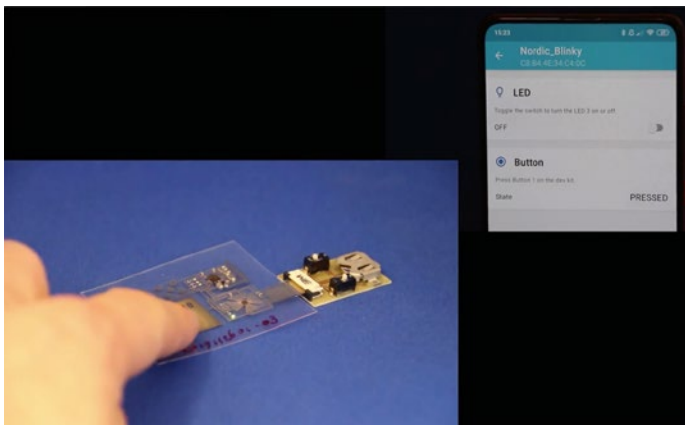

Fig. 7: LED off, button pressed