Printed Pressure Sensors: Industrial Case Studies

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Recently large-scale printed pressure / force sensors are intriguing electronics community because of their unmet properties, i.e., flexibility, tunability, large area, cost-effective fabrication and high integration potential. CSEM deals with printing technologies for more than a decade mastering printing materials and substrates, devices and systems and its functionalities. Here we are presenting two printed pressure / force sensor prototypes showing their functional tunability and high system integration potential in robotic and smart shelf applications. The prototypes are realized in collaboration between CSEM and F&P Robotic AG and Turck duotec SA, respectively. Both cases demonstrate the advantages of an innovative hybrid system integration approach – integration of large area printed components and standard electronics. Thus, a new developed systems contains best of both worlds, i.e., (conventional) high-density SMD electronics and (emerging) large area printed electronics.

Recently printed pressure / force sensors rise significant interest among the electronics community because of its high flexibility and high system integration potential. In a nutshell, CSEM's screen printed pressure sensors consists of two flexible polymer foils; one with interdigitated electrodes and the other one with patterned resistive paste. After fine layer thickness tuning, though thickness/resistance adjusting, foils are assembled. The interface with the external electronics is provided through the connectors suitable for overmolding. This way, hybrid integration between printed and conventional electronics is established.

Robots have been working in the industrial production for decades, however they have been doing this in an isolated environment *i.e.*, with no humans around. In recent years, the field of collaborative robotics has gained a lot of attention and robots started working alongside their human co-workers. This change demands the robots to be aware of their surroundings in a much more comprehensive way. The Swiss SME F&P Robotics AG has been aware of this challenge in their customers' industry and is producing service robots and technology assisting, helping and facilitating activities from people's daily lives. Through the integration of flexible pressure sensors into the robotic fingers, F&P Robotics AG strives to improve its products further.

Figure 1: Pressure sensors for robotic grippers (F&P Robotic case).

The realized fingers shown in Figure 1 consists of 20 pressure sensor pixels which are printed on a flexible and stretchable foil. CSEM conducted the design of the sensors, their fabrication by screen printing and their characterization. The resulting pressure sensor is thin (below 400 µm thickness), flexible, easy to customize and has a sufficiently large active area in order to provide pressure mapping information (*i.e.*, position of the pressure stimulus) over the contact surface of the robot finger. The sensor is molded on the 3D printed "bone" and is interfaced with the robot electronic hardware. In this configuration the sensor is sensitive to forces between 0.1 N and 10 N. The novel technology will allow F&P Robotics AG to become a game changer in this industry by providing robots equipped with cost-effective and large area printed pressure sensors which add sensing functionalities, manipulating and correction capabilities. These demonstrators will open new market opportunities for the collaborative robot from F&P Robotics AG, especially in the human environment and food handling segments.

On the other hand, multifunctional smart shelves are envisioned to be effective solution used in various domains, *e.g.*, in shops where they can easily serve as indicators for products missing. Less pressure indicates that the product is removed or half empty – so called "out-of-the-shelf case", another application case is "track-and-trace", where the missing item triggers a warning alarm, if not returned on the original place after a certain time.

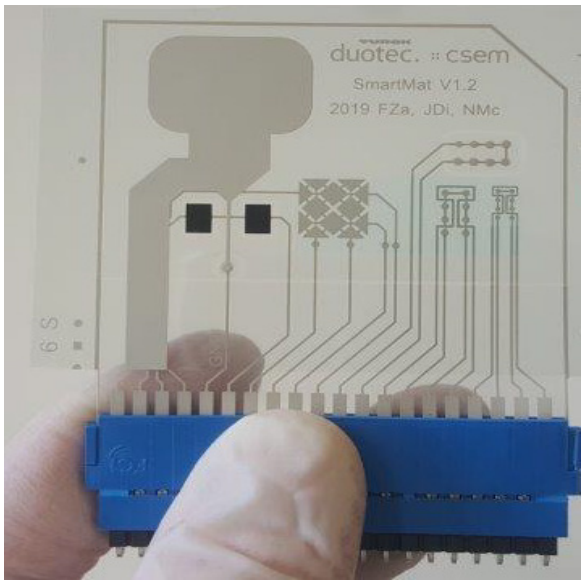

Figure 2: Pressure sensors (test features) for smart shelfs (Turck duotec case).

In Figure 2, printed test features contain printed pressure / force sensors, touch sensors and process integration test features (from left to right). The test features are further processed by Turck duotec SA to integrate the standard electronics interface and overmold the electronics including parts of the sensor foil. The full system is characterized electronically before and after environmental stress tests.

The shown cases demonstrated:

- Printed sensors tunability, from high to low/medium sensitivity, and
- High integration potential

CSEM and its partners are pursuing this integration approach, to offer new innovative products to the market.

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• F&P Robotics AG, Switzerland

•• Turck duotec SA, Switzerland