PyzoFlex® matrix: How to combine printed ferroelectric sensors and organic transistors for vital parameter, tactile pressure and proximity sensing

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Flexible sensors impress with their outstanding properties; as they allow cost-effective and environmentally friendly production of large-area, flexible and, when fabricated on ultrathin, highly conformable or even stretchable substrates. These special properties enable an unprecedented integration possibility of sensor technology on complex-shaped objects, and pave the way for multi-stimuli responsive electronic skins used in human machine interfaces, soft robotics, prosthetics, implantable, wearable and physiological sensors, and sensor networks for the internet of things or structural health monitoring.

One transducer material that has proven to be very effective in many of the above-mentioned applications is the ferroelectric co-polymer P(VDF-TrFE). It can be printed at high resolution on various substrates in different form factors and is sensitive to pressure / force, strain, vibration / structure-borne sound as well as proximity / MIR radiation owing to its piezo- and pyroelectric nature [1].

An area where ferroelectric e-skins with low weight and high wearing comfort are of particular interest is the monitoring of human vital parameters such as pulse rate, blood pressure, tactile pressure or proximity signals at the point of care/living. Since vital parameter transducers should be highly conformable to the human body and provide a high spatial and temporal resolution, active addressing of the pixels in the ferroelectric transducer matrix in real time is inevitable. Such active addressing in e-skins is best achieved with organic thin film transistors, which, due to their compatibility with flexible, ultrathin or stretchable substrates, are the ideal counterparts for flexible ferroelectric transducers.

Here I will demonstrate several combinations of ferroelectric polymer transducers with organic thin film transistors on flexible substrates for tactile pressure sensing, proximity detection, pulse rate as well as blood pressure monitoring.

First, the basics of our printed ferroelectric sensor technology PyzoFlex® highlighting its scalable manufacturing and versatile application scenarios focussing on biosignal monitoring via the human pulse wave are presented [2]. Then I will show an ultra-compliant active-matrix tactile pressure sensor, where organic transistors are monolithically integrated with the ferroelectric transducers on a just 1 µm thin polymer substrate. More than 100 pixels at a pitch of ≈ 3 mm are addressed in this way. Advanced shadow-mask processes allow for a transistor channel length of < 20 µm and overlays < 100 µm, enabling operating frequencies in the 10 kHz regime and frame rates > 100 Hz [3].

Finally, I will demonstrate an in-pixel amplified actively addressed flexible proximity-sensing surface for process control, work security and robotics based on the integration of an all-printed organic thin film transistor backplane with an all-printed pyroelectric sensor frontplane. The system can detect a human hand approaching from different directions and track the position of a movable heat source up to a distance of around 0.4 m at a readout speed of 100 frames per second [4].

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