PyzoFlex®

and the world of Human Machine Interfaces

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We demonstrate the development of a complex smart integrated sensor system that is produced by a screen printing technique. The sensor build-up can be described as a sandwich structure of four layers which can easily be printed onto any material as flexible plastic foils, paper or textiles and wooden surfaces. For realizing the sensor, only four functional inks are used: i) a sensor ink consisting of the ferroelectric material P(VDF:TrFE), ii) a conductive PEDOT:PSS polymer ink and iii) a conductive carbon paste, severing as bottom- and top electrodes, respectively. The stack of these three layers forms a capacitor where pressure- as well as temperature induced charge separation in the ferroelectric sensor layer lead to a voltage signal at the electrodes. Finally an Ag-paste (iv) for connecting the sensor to a read-out electronics is deposited.

Within this work we developed a ferroelectric sensor foil, including piezo- and pyroelectric pixels (sensitive to pressure changes and impinging infrared light) optionally combined with printed transistors for impedance matching and electrochromic display pixels for visualization. Thereby a novel input technology – a force-sensing human-machine interface called PyzoFlex® – based on this piezoelectric sensor foil was established. The foil is bendable, energy-efficient, and can be realized by a low-cost industrial printing process, e.g. screen printing for sheet to sheet production with a potential for up-scaling the fabrication process to R2R.

Principle & Basics

The piezoelectric effect can be found in any ferroelectric material. Any mechanic stress or force (e.g., touch) applied will result in a change of the electric field (Fig. 1). This electric field variation is proportional to the mechanic deformation. Therefore, the piezoelectric effect can be used to measure pressure changes efficiently.

P(VDF-TrFE) copolymers (Fig. 2) have become very attractive as functional materials for high-tech applications due to a number of excellent inherent physical properties. Apart from the usage as high-k gate dielectrics in logic gates based on miniaturized organic thin film transistors, a remnant polarization charge with more than 100 mC/m^2 qualifies these copolymers as charge storage dielectrics in non-volatile memory elements, and high piezo- and pyroelectric coefficients (up to 40 µC/Km^2) make them attractive for sensor- and transducer based organic devices.

In Fig.3 the voltage output of the PVDF-Sensor is shown

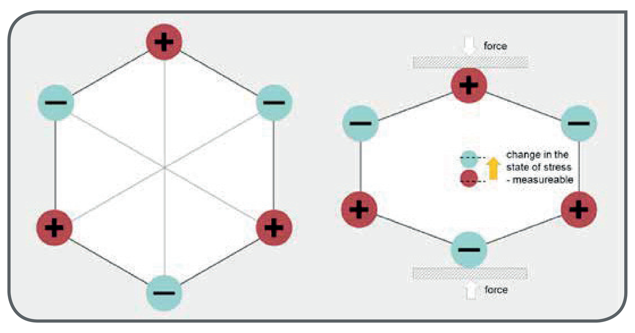


Figure 1

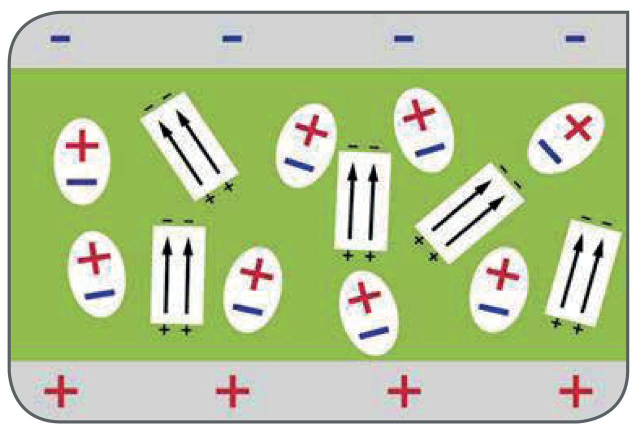


Figure 2: P(VDF-TrFE)
Poly(vinylidenfluorid-Trifluoroethylen)

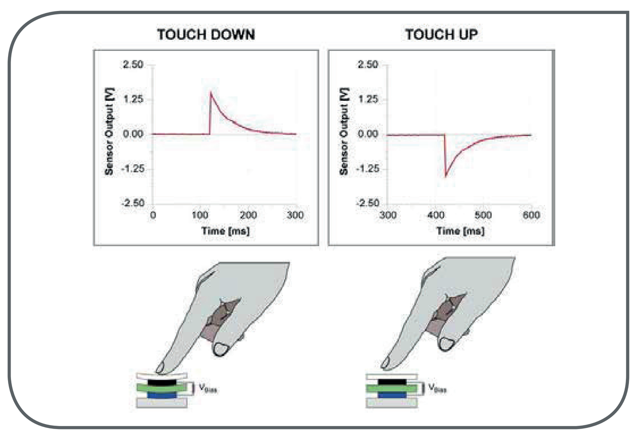


Figure 3

Production

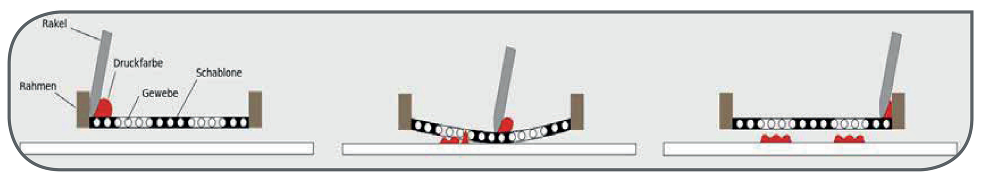


Figure 4
Substrate:
Melinex ST 726

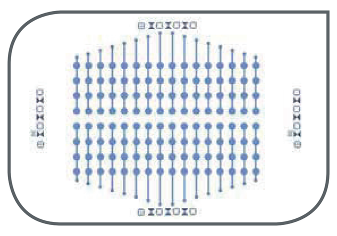
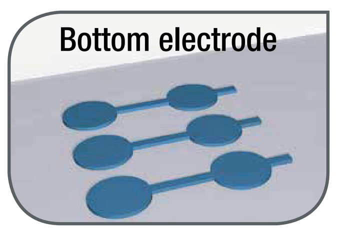


Figure 5
Bottom electrode

PEDOT: SV3/4 (Heraeus)
100 °C for ≥ 3 Minutes



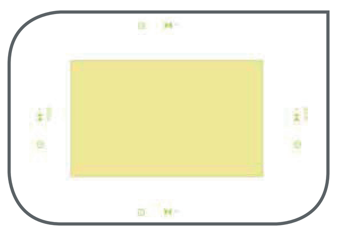
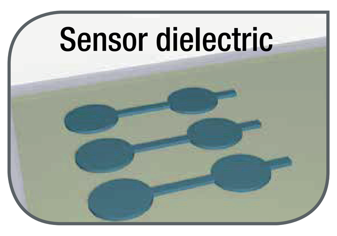


Figure 6
Sensor dielectric

PVDF:TrFE: own Synthesis
100 °C for ≥ 5 Minutes



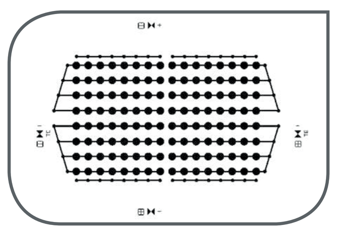
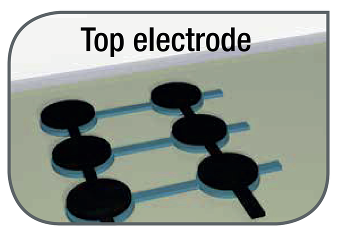


Figure 7
Top electrode

Carbon:7201
100 °C for ≥ 3 Minutes



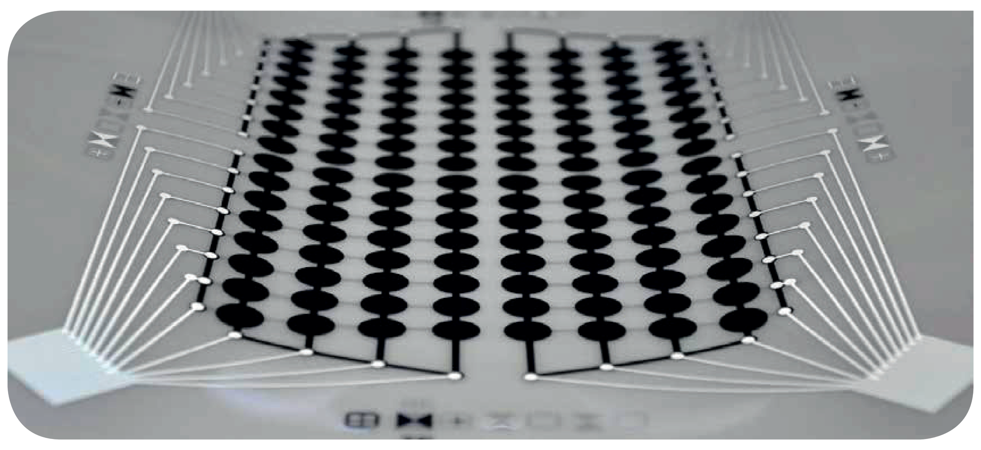


Figure 8
Conductor-Line:
Ag: DuPont 5000
100 °C for ≥ 3 Minutes

Soft & Hardware

Sensing Electronics (Figure 9):
The equivalent circuit of a piezoelectric sensor is a current source with an internal resistance Rs (1GΩ) and an internal capacitance Cs (1nF).
(a)

Touching the foil generates only a very small amount of energy, which is difficult to measure. Therefore an impedance converter is used to amplify the sensor signal.
(b)

In a next step, the signal noise gets reduced. The electrical noise is around 50Hz in the signal spectrum – therefore a 50 Hz Notch filter is used to remove this noise. (c)

In a last step, an offset and attenuation is applied to the signal to satisfy the measurement range (0 to 3.3 V) of the micro-controllers internal analog to digital converter.
(d)

For the current prototype a highly energy-efficient 32-bit Cortex-M3 microcontroller from ATMEL is used.
(e)

The internal resistance and the internal capacitance of the sensor are dependent on the physical dimensions, the electrical conductivity and the permittivity of the applied material.

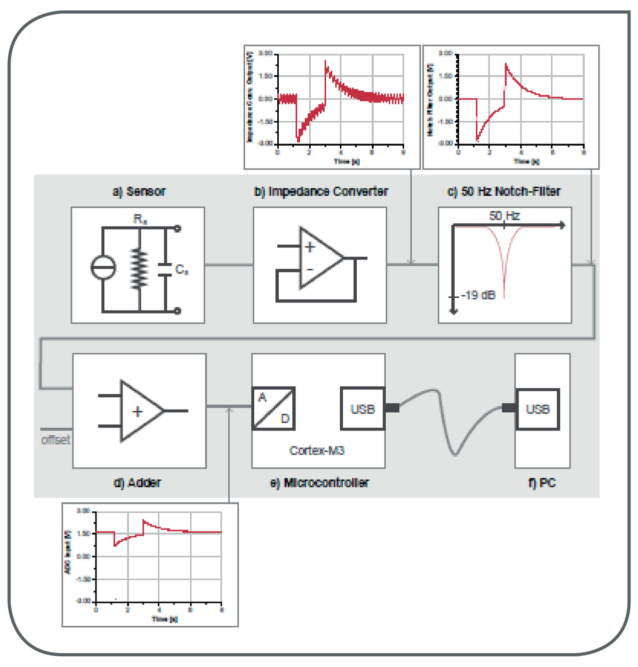


Figure 9

Scanning a Single Touchpoint (Figure10):

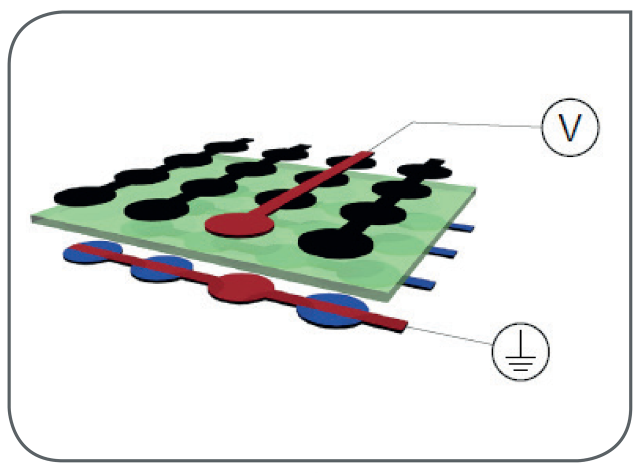
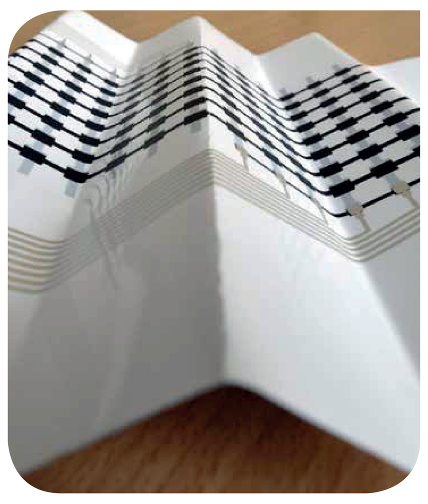


Figure 10

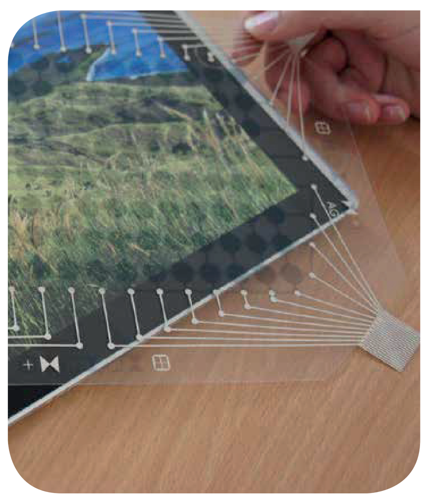
Advantages and Applications

Low costs due to printing processes

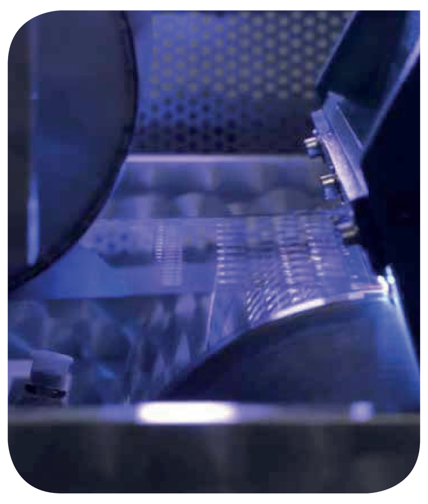


Printable on any substrate, even paper Low energy consumption – even "energy harvesting" possible

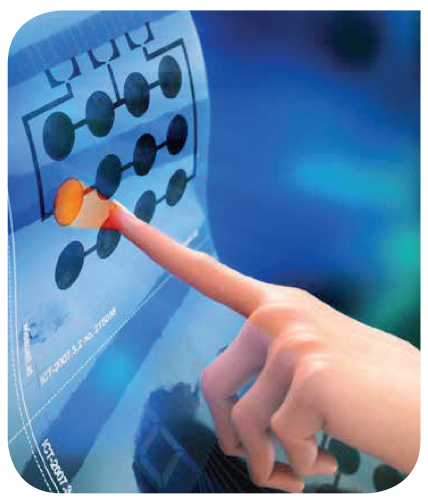
Flexible and bendable



Transparent (currently 85 %; ITO-free)



Scalability



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