PyzoFlex®
dynamic sensing
energy harvesting
pressure & temperature
printed & flexible

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Data sheet

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The patented PyzoFlex® technology is an affordable, printable sensor technology that can be implemented on an industrial scale. It allows the large-scale and accurate measurement of temperature and pressure changes in objects and their environment based on the pyro- and/or piezoelectric effect. The technology is based on ferroelectric polymers, which are applied using a cost-effective screen printing method. These films can detect localized pressure and temperature changes with high precision. The performance of the PyzoFlex® technology within specific applications strongly depends on the mechanical design (conversion of external stimuli into tiny mechanical deformations) and therefore cannot be generalised. All the data presented within this data sheet are based on measurements of PyzoFlex®-sensors composed of the ferroelectric copolymer PVDF:TrFE = 70:30 printed on PET-substrates.

Measured physical properties of screen-printed PyzoFlex® sensors based on PVDF:TrFE=70:30				
	min.	**typical**	max.	Unit
Recommended poling field	100	**150**	200	MV/m
Displacement	50	**60**	66	mC/m^2
Coercive field @ 10Hz	46	**55**	60	MV/m
Pyroelectric coefficient @ 25°C	28,5	**34**	37,5	$\mu C/m^2K$
Pyroelectric coefficient from –90°C to +90°C	12 — 52	**15 — 62**	16 — 67	$\mu C/m^2K$
Piezoelectric coefficient d_{33}	-21	**-25**	-27,4	pC/N
Tested pressure range*	30m — 40k			N/cm^2
Electromechanic coupling coefficient k_{33} (1Hz — 1kHz)*	0,15	**0,16**	0,17	-
Curie Temperature	103	**104**	105	°C
Standard PVDF:TrFE layer thickness	3	**5**	15	µm
Capacity at standard layer thickness	2	**1,33**	0,45	nF/cm^2
Capacity (thickness normalized)	6,21	**6,64**	6,79	$nF/cm^2\mu m^{-1}$
Permittivity @ 1kHz (poled)	7,2	**7,5**	7,9	-
Permittivity @ 1kHz (unpoled)	10,9	**11,4**	12,0	-
Frequency response**	100µ — 1M			Hz
Tunable properties based on polymer-composition				
VDF content of PVDF:TrFE	55, 70, 80			%mol
Curie temperature	62 – 132			°C
Coercive field (quasi-static)	46 — 57			mV/m
Displacement	48 — 80			mC/m^2
Piezoelectric coefficient d_{33}	-26 — -30			pC/N

* Due to the flexibility of PyzoFlex®, the conversion of force to mechanical deformation can be enhanced by employing appropriate mechanical design.

** The parameter limits are determined by available measurement equipment and its measurement ranges.

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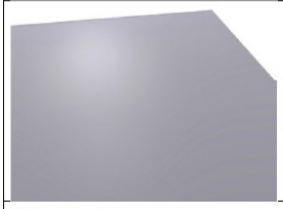
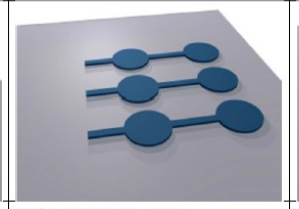
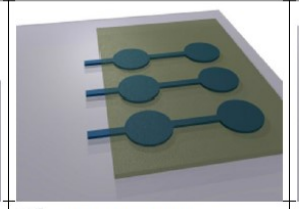
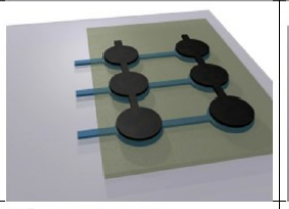
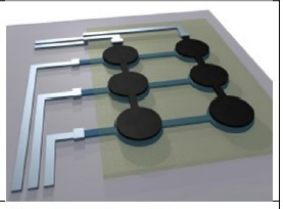
Standard PyzoFlex® build up by screen-printing:

Substrate	1st Electrode	Active Material	2nd Electrode	Connections
				
Plastic, paper, textile, glass, metal, transfer foils …	PEDOT: PSS (conductive, transparent polymer)	Copolymer: PVDF:TrFE (patented synthesis)	PEDOT:PSS (for semi-transparent sensors) Carbon	Ag lines for connection to electronics

Ageing analysis of PyzoFlex®

A set of tests was used to determine if the material has potential for automotive applications. These tests are summarized in the following table:

Test ID	Test name	Description
TS	Temperature Storage	Keeping samples at 105°C for 24 hours
HW	Hot Water Test	Keeping samples in water at 99.9°C for 1 hour
1000H	1000 Hours Test	Keeping samples at 85°C and 85% humidity for 1000 hours (42 days)
ThSh	Thermal Shock	The samples are kept at alternating low and high temperatures. During the cold phase the samples are kept at -40°C for 30 min. During the hot phase they are kept at +85°C for 30 min. The test lasts 11 days.
UP	Uniaxial Pressure Test	A static pressure of 0.1 MPa is applied for 240 hours (10 days) at 85°C
MA	Multiple Mechanical Actuation Test	106 actuations are performed at a frequency of 1Hz. Within each actuation the pressure of p=0.01MPa at room temperature is applied.
Shr.	Shrinkage Test	A sample of a fixed size is placed into an oven at 90°C for 30 min and the ratio of the size after and before the test is determined.
Fl.	Flammability Test	The sample stripe of a prescribed length is set afire; the speed of the flame front is measured and classified by integers from 0 to 5.

In addition to the tests described in the previous table, the ageing of the sensor is checked by measuring it´s piezoelectric modulus and defining the aging factor as follows:

$$AF = \frac{d_{33}^{(after)} - d_{33}^{(before)}}{d_{33}^{(before)}} \text{x } 100$$

where AF is the ageing factor and d_{33} is the piezoelectric modulus of the sensor. The superscripts „before and „after“ indicate, if the corresponding data is measured before or after the ageing process.

Test ID	Aging factor [%]	Acceptability [Yes/No]
TS	-3.2 ± 0.4	Yes
HW	2.3 ± 0.1	Yes
1000H	6 ± 0.6	Yes
ThSh	-8.7 ± 0.8	Yes
UP	-2.8 ± 0.2	Yes
MA	4.8 ± 0.5	Yes
Shr	0	Yes
Fl.	Self-extinguishing, non- flammable	Yes

According to the tested parameters PyzoFlex® has potential for automotive applications.

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