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PZT-polymer composites: material combinations and design routes for optimal device performance

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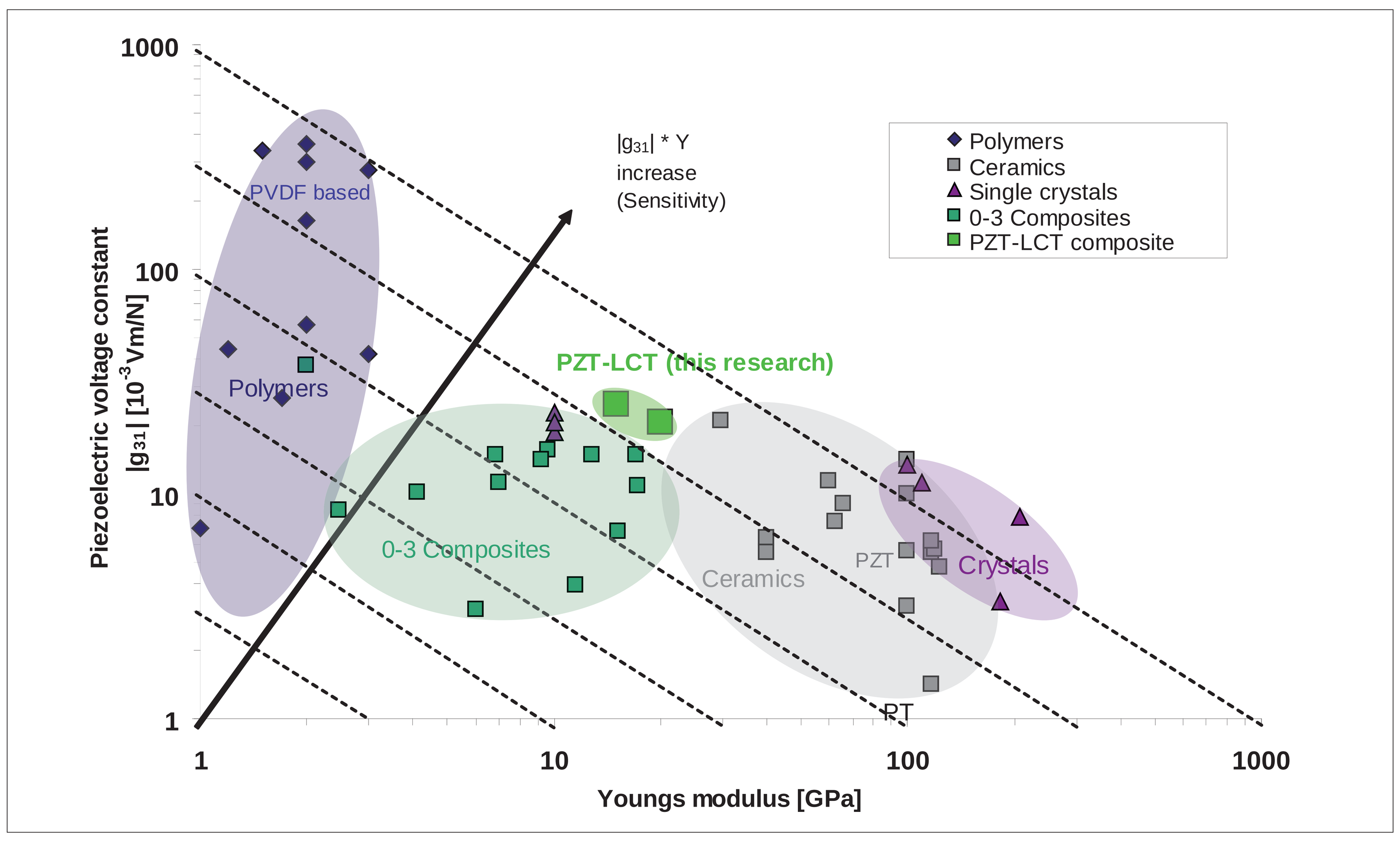
Introduction

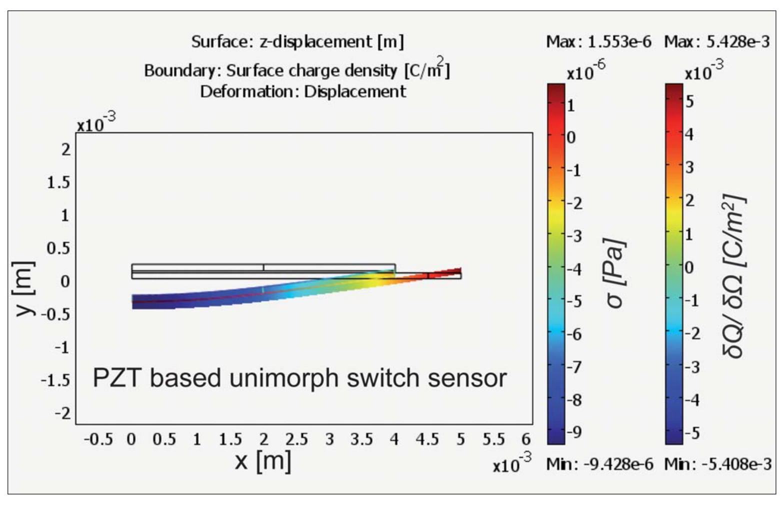
Composites of PZT ceramic particles in a polymer matrix offer interesting sensorial properties as well as the possibility of integrating sensor elements into structural parts. In the case of fibre composite structures, conventional piezoelectric materials, such as PZT ceramics and PVDF polymers, must be adhered to a structural element. PZT- polymer composites however, can be integrated in the structure itself. This poster presents properties of PZT- polymer composites as well as their performance in a simple bending disk type pressure sensor, which can be used as a hand pressed switch.

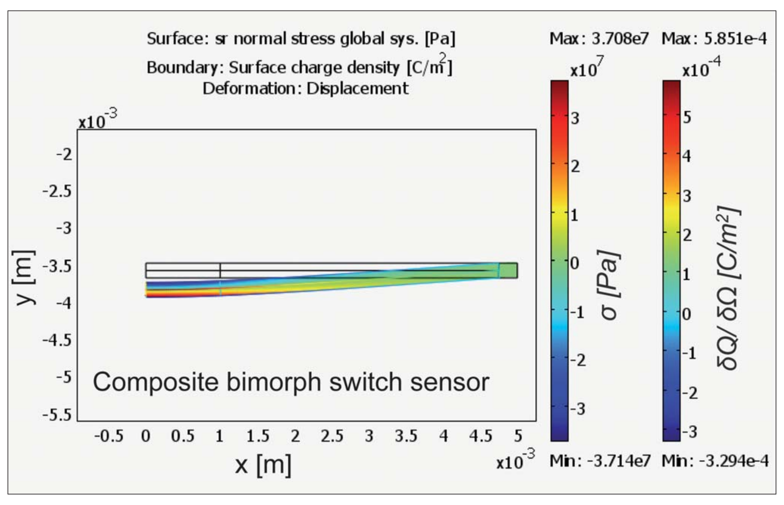
	PZT	PVDF	PZT – LCR composites
d_{33} (actuator property)	480 pC/N	20 pC/N	25 pC/N
g_{33} (sensor property)	~28 mV.m/N	220 mV.m/N	75 mV.m/N
Stiffness (Y_{11})	60 GPa	2GPa	20 GPa
Tensile strength	<< 50 MPa	60 MPa	< 60 MPa
Ductility (ε_{br})	~0.05 %	5 %	> 1 %
Temperature stability	< 200 °C	< 100 °C	170 °C
Cost	High	High	Low

The sensitivity to deformation of the piezoelectric sensor can be increased by maximising the product $g_{31}Y_{11}$. Therefore, PZT polymer composites in which the matrix phase comprises of a high stiffness polymer exhibit excellent overall sensor properties. Exceptionally suitable polymers in this case are high performance polymers such as the family of novel liquid crystal thermosetting resins [1,2].

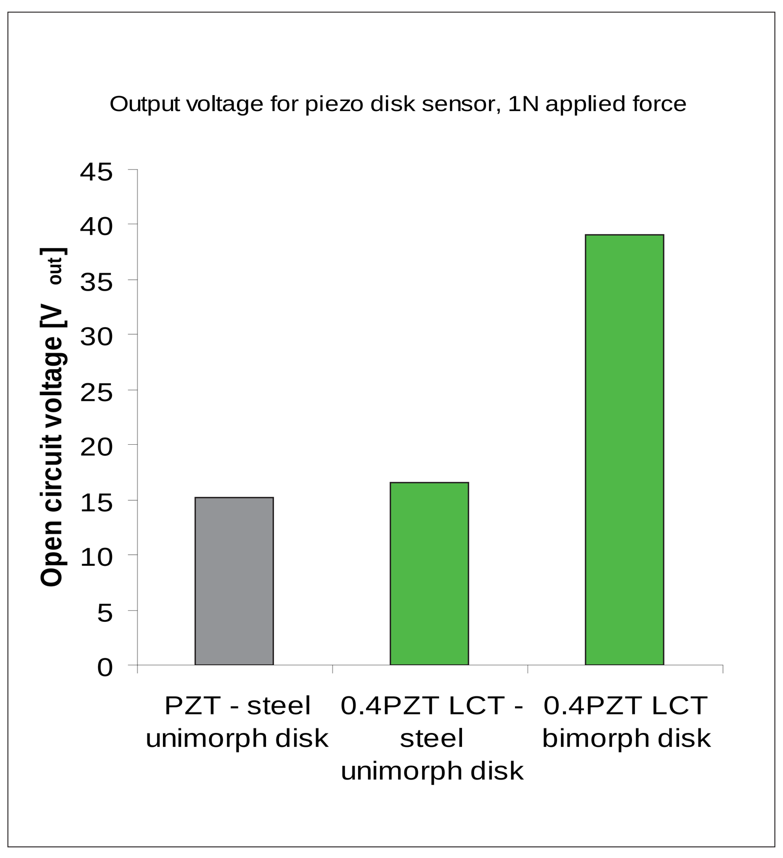


Sensor design



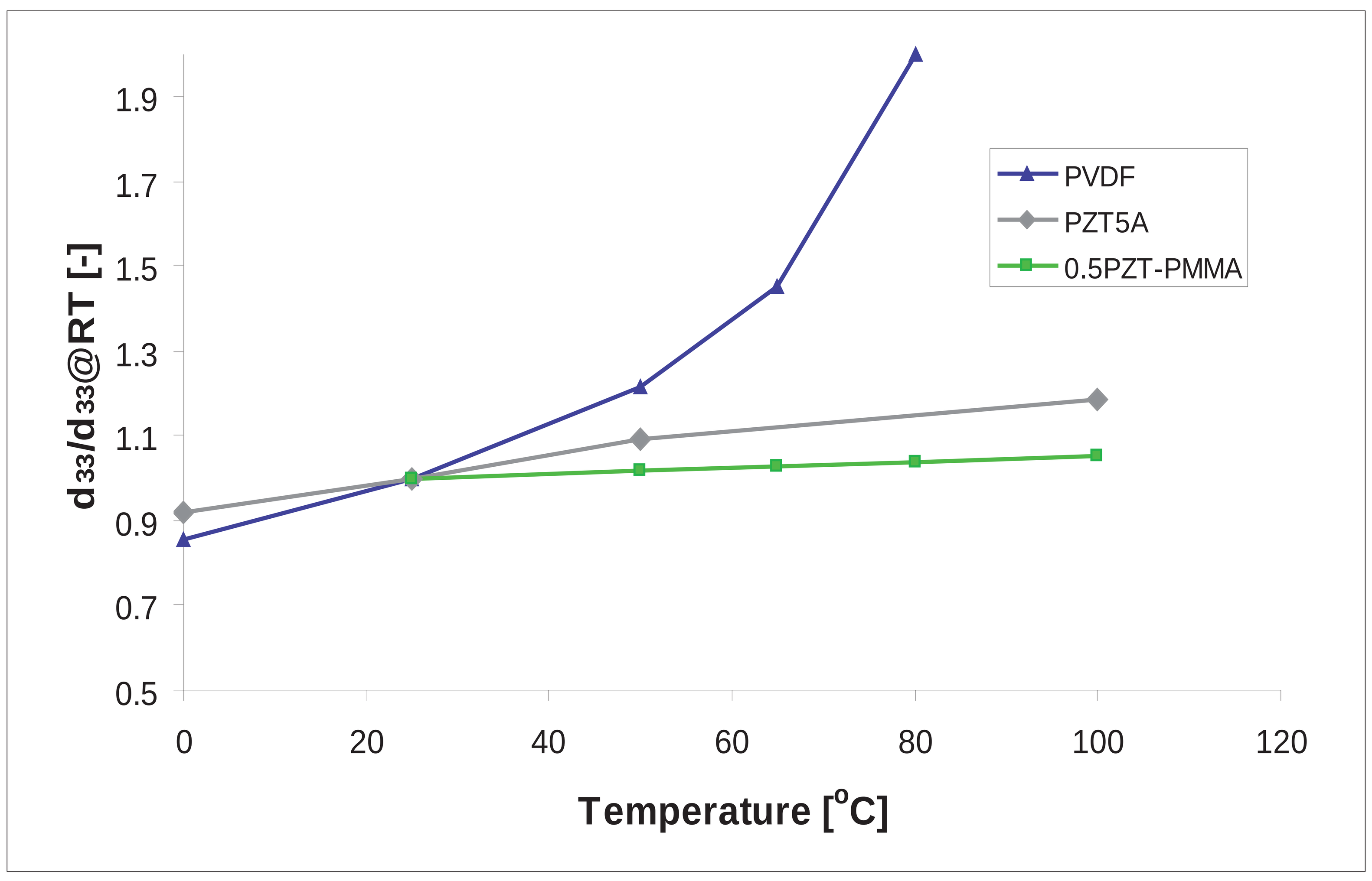


Because of their brittle nature, piezoceramic sensor disks can only be subjected to compressive stress, limiting the design to a unimorph bender, whereas 0-3 composite sensors can be applied as bimorphs, doubling the output voltage of the sensor. New and improved designs are also made possible by the compatibility of composites with standard (thermoplastic) polymer processing techniques.



Temperature Stability

Another advantage of piezoelectric composites is the limited temperature dependence compared to both PZT ceramics [3] and PVDF polymers [4]. This will lead to a more stable output signal of a sensor made from a composite material, thus enhancing the sensorial properties of the component.



Conclusions

It has been shown that composite materials of piezoelectric ceramic particles in a polymer matrix posses excellent overall sensorial properties. The product $g_{31}Y_{11}$ is comparable to state of the art piezoelectric materials such as PZT ceramics and polymers of the PVDF-family. By adapting the design of a sensor (switch) disk to the composite material, more than double the output voltage may be achieved, compared to a standard PZT disk sensor. A broader range of sensor designs are possible due to the relative ease of processing of the composites. Furthermore, the temperature stability of the composite leads to a less temperature sensitive response, which is favourable for many sensor applications.

References

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