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R & D Piezoproducts

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Overview on the Application of
Piezoceramics Bending Actuators - Piezoceramics at Argillon

Abstract

Overview on the Application of Piezoceramics Bending Actuators

- Piezoeffect
- Bending actuator structure techniques
- Piezoproducts
- Applications of piezoelectric bending actuators

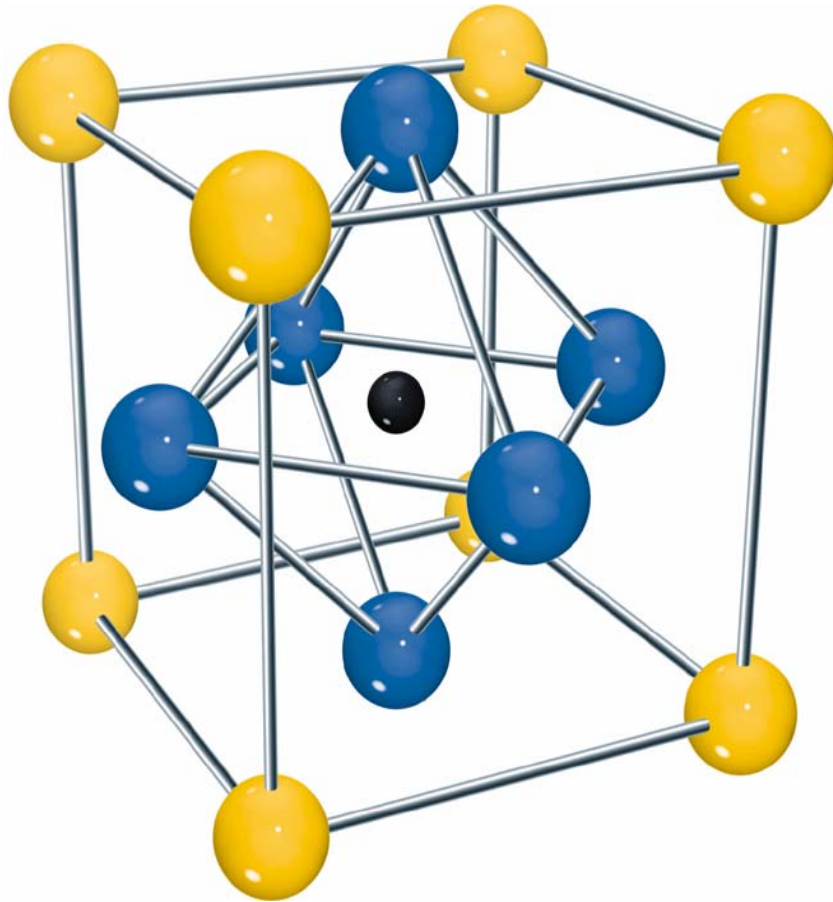


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PZT - Perovskite crystal structure



- $\text{Pb}(\text{Zr}_x \text{Ti}_{1-x})\text{O}_3$
- Lead (Pb^{2+})
- Oxygen (O^{2-})
- Zirconium (Zr^{4+})
- or Titanium (Ti^{4+})



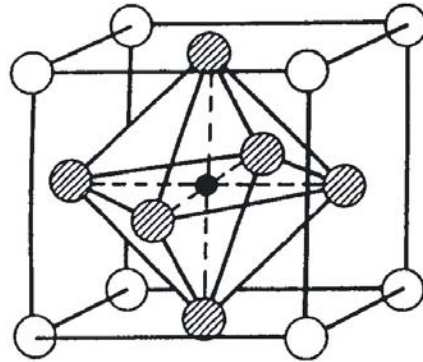
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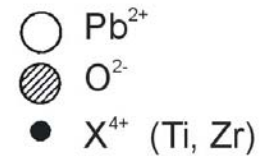
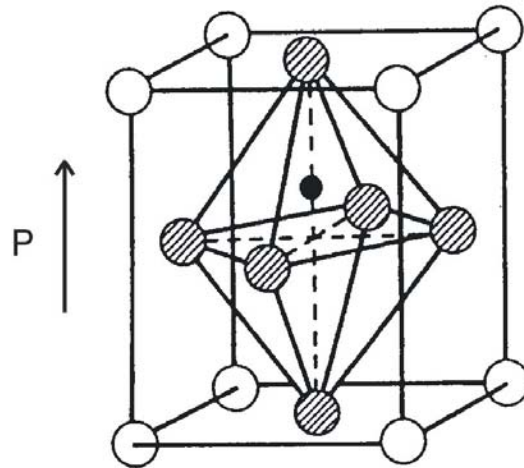
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Piezoelectric effect - Curie temperature

Perovskite Crystal Structure



PZT Cubic crystal
($T > T_c$)



PZT Tetragonal crystal
($T < \bar{T}_c$, Spontaneous Polarisation)



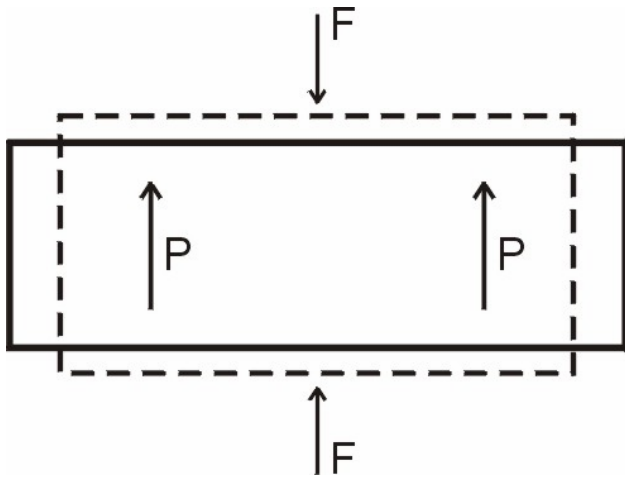
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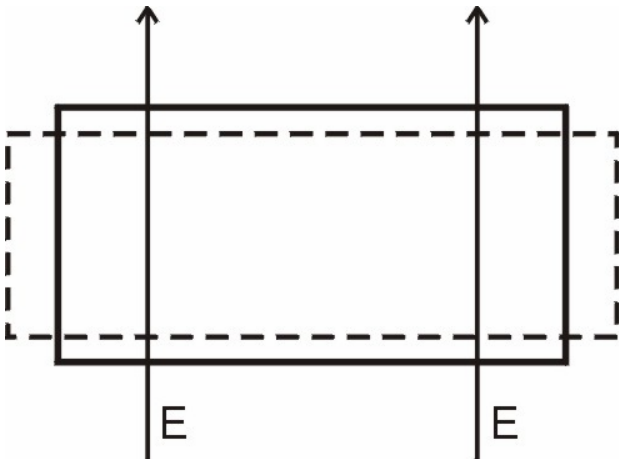
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Piezoelectric effect

Piezoelectric effect



Inverse piezoelectric effect



Conversion of a mechanical stress into a electrical signal

Mechanical output produced by an electrical input.



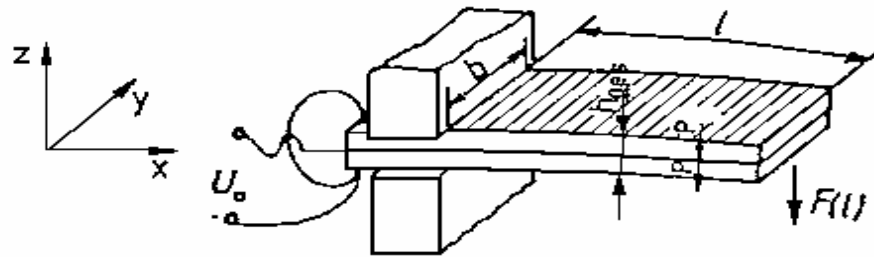
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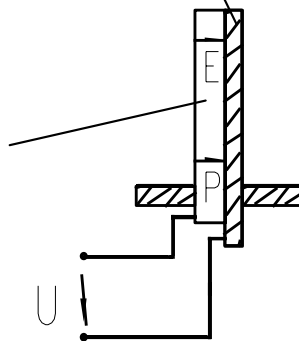
Bending actuator structure techniques

Bimorph

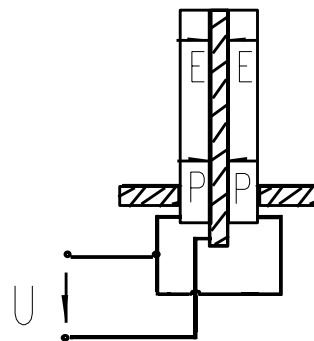


inactive
Layer

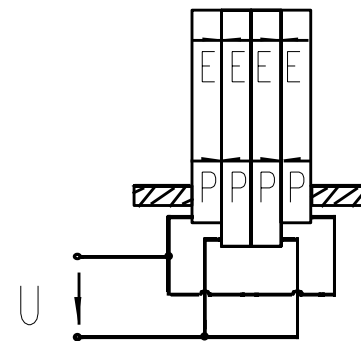
Piezo-
ceramic



Monomorph



Trimorph



Multimorph



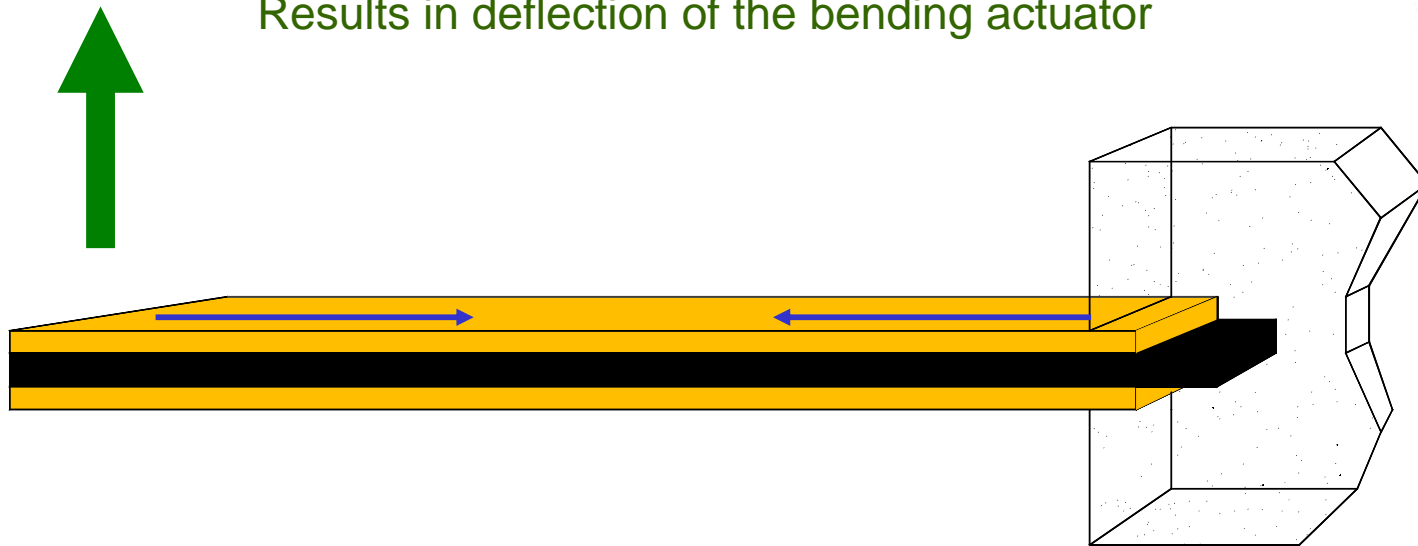
Piezoproducts

Bending actuator

Deflection of a trimorph bending actuator

Contraction of the ceramic by applying the operating voltage

Results in deflection of the bending actuator



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Bending actuator

Deflection of a trimorph bending actuator

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Results in deflection of the bending actuator

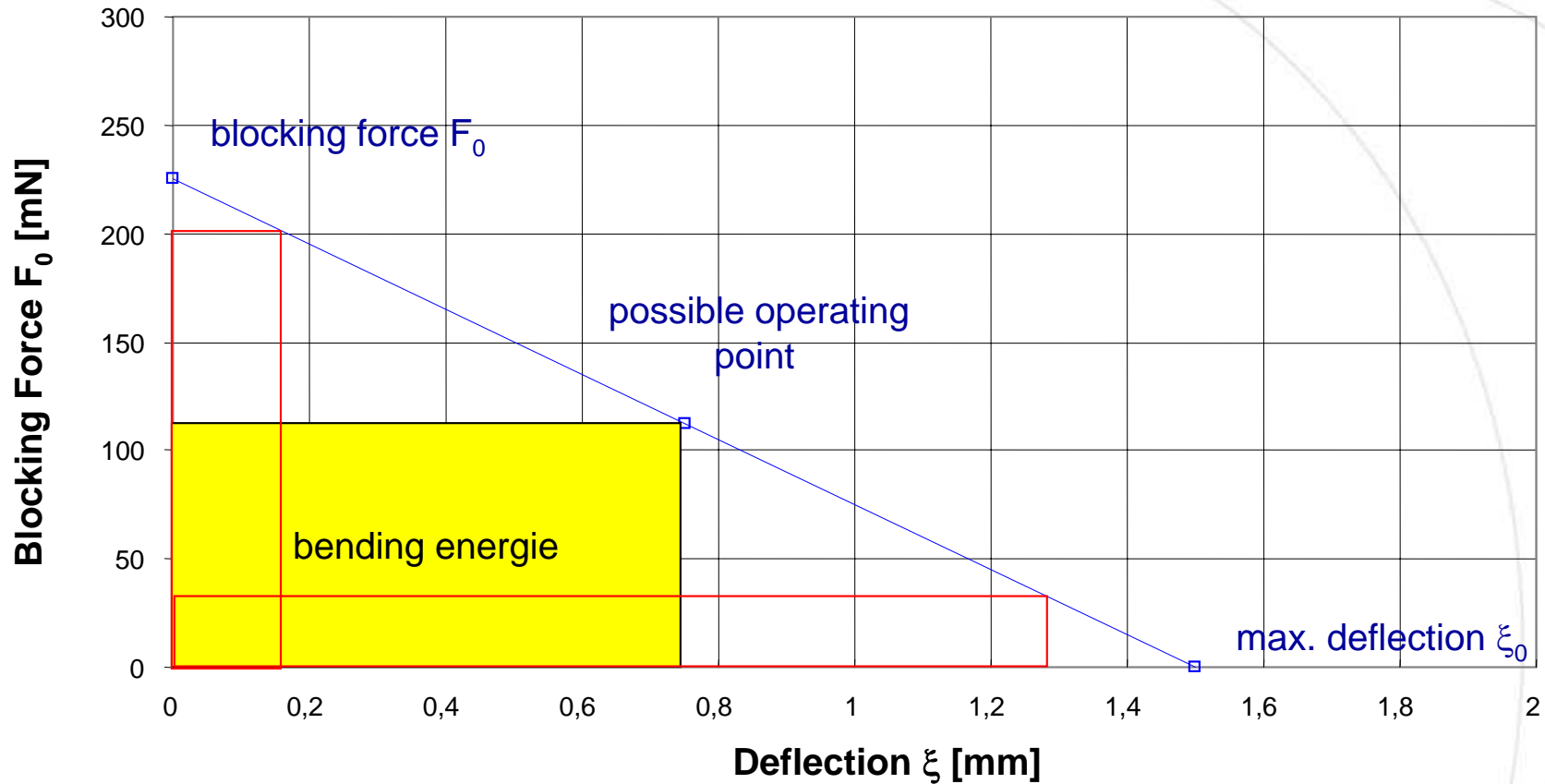


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Bending actuator - force-deflection characteristic



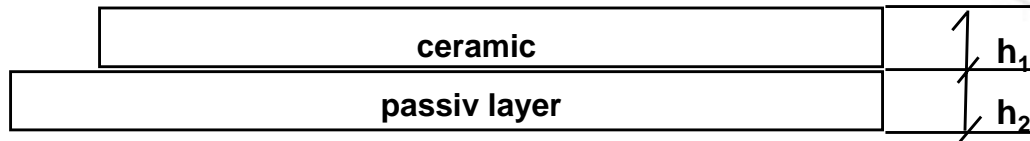
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Bending actuator - force-deflection characteristic

monomorph bending actuator



a) maximum deflection ξ_0

$$\xi_0 = \frac{3}{4} d_{31} U (l^2 / h_1^2) fE$$

$$fE = \frac{4 a c (1 + a)}{4 a c (1 + a)^2 + (1 - a^2 c)^2}$$

$$a = \frac{h_2}{h_1}$$

a) blocking force F_0

$$F_0 = \frac{3}{2} d_{31} U b E_1 (h_1 / l) f_m$$

$$f_m = \frac{a c (1 + a)}{2 (1 + a c)}$$

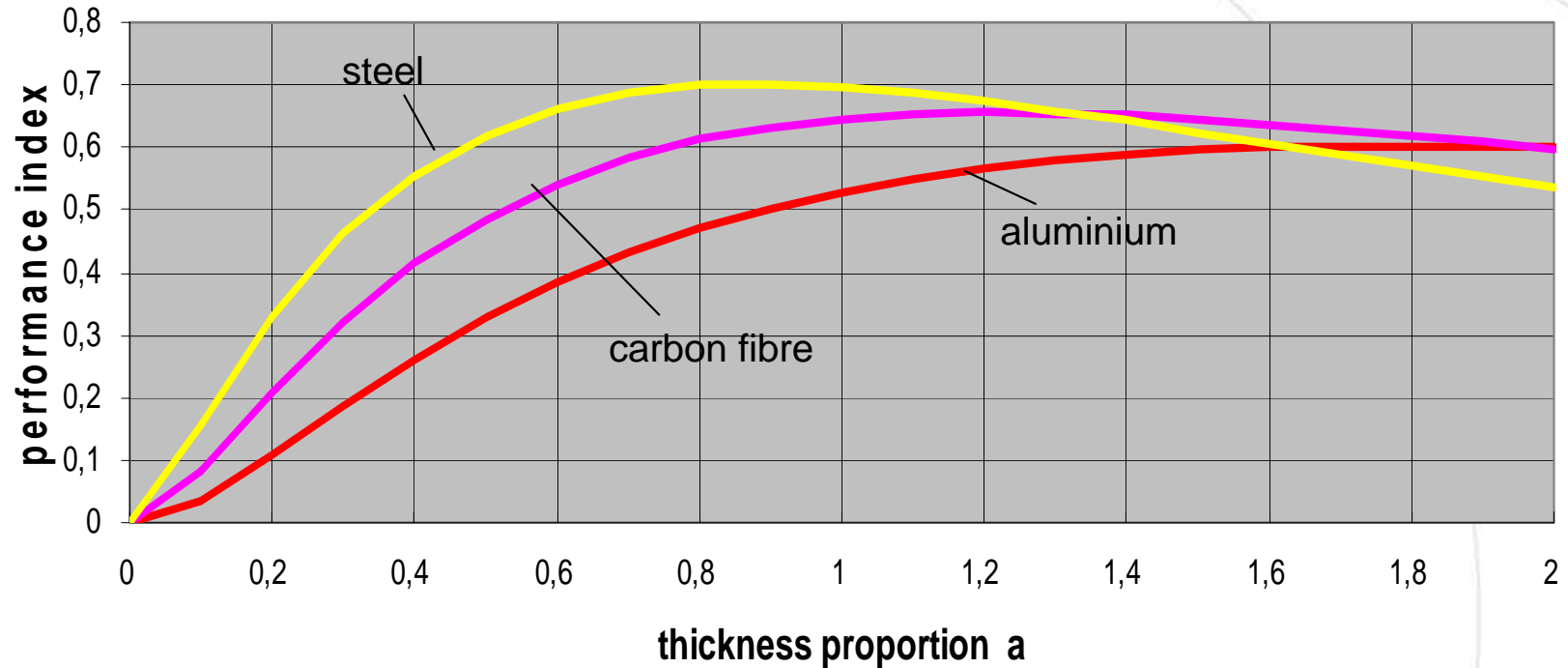
$$c = \frac{E_2}{E_1}$$



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Bending actuator - Performance index

performance index = blocking force * max. deflection

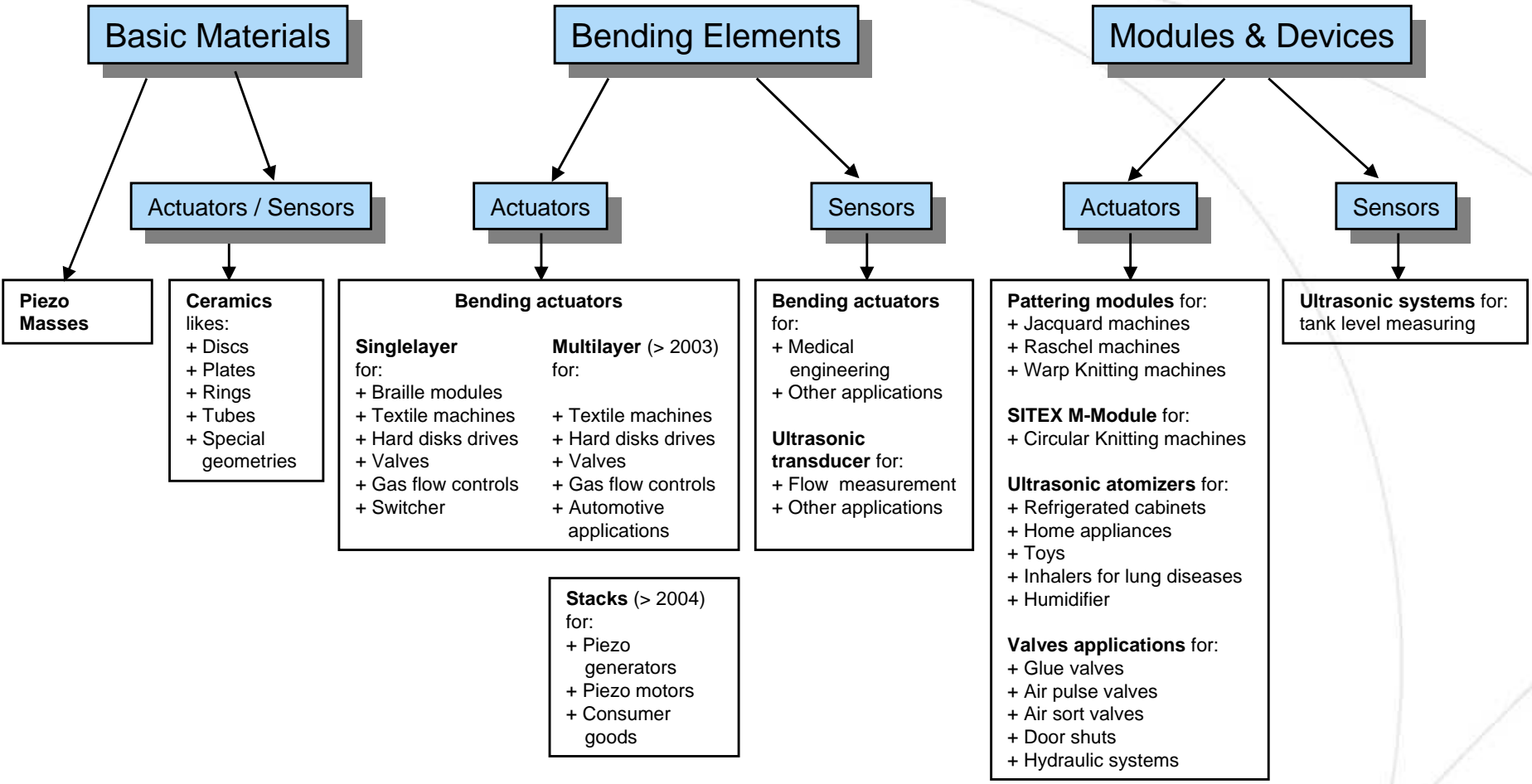


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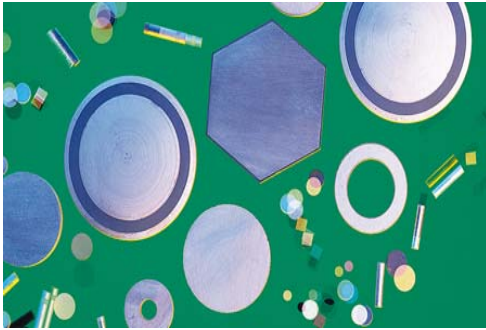
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Piezoproducts - Portfolio



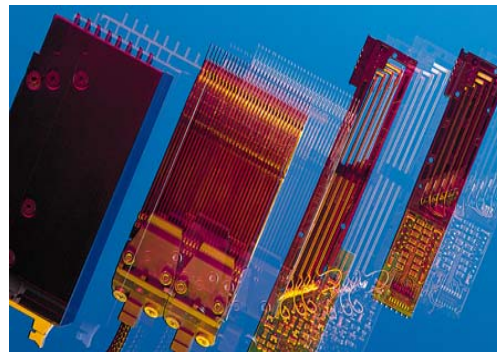
Divided into three groups



Basic Materials



Bending Elements



Modules & Devices



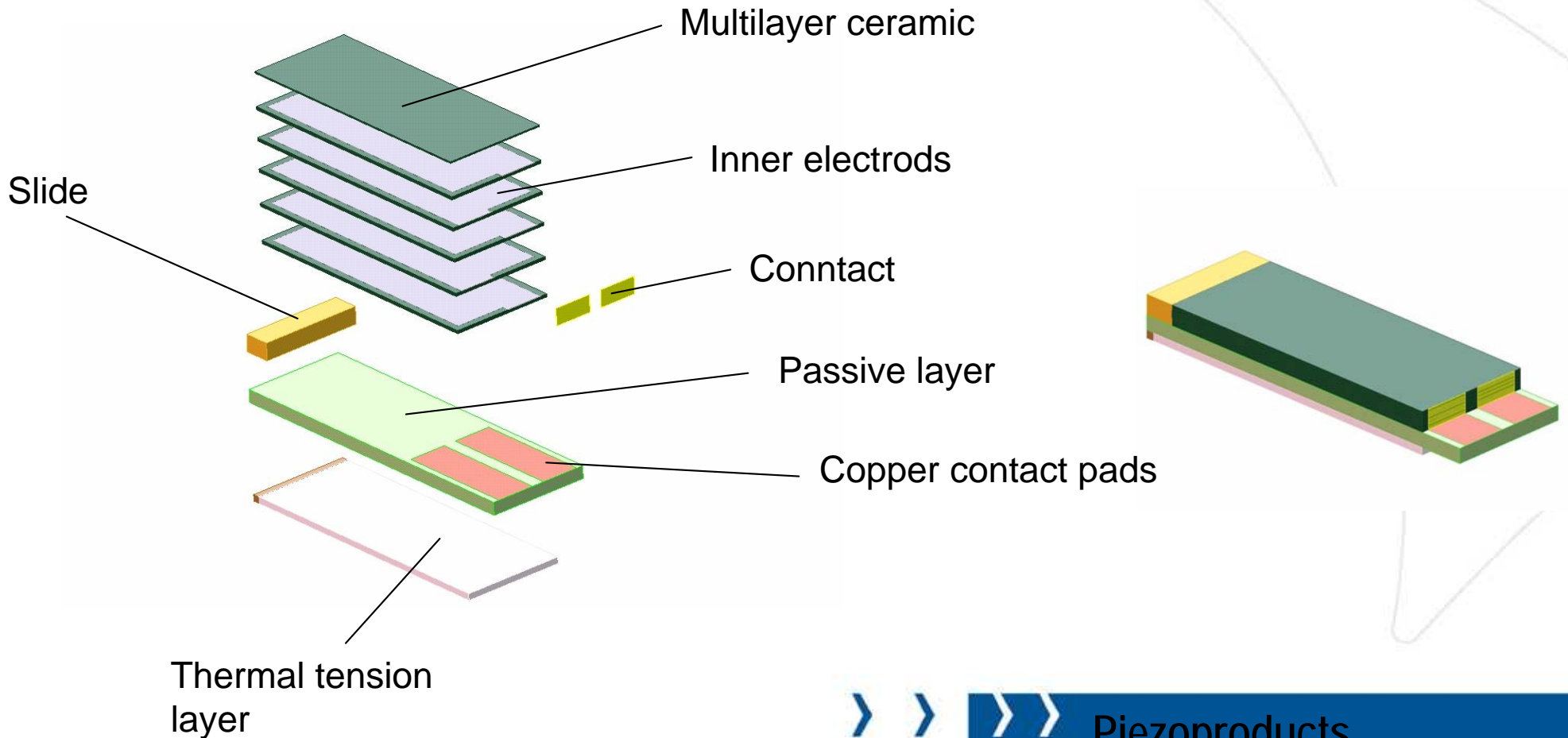
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Multilayer bending actuator

Design of a monomorph multilayer bending actuator with thermal tension adjustment

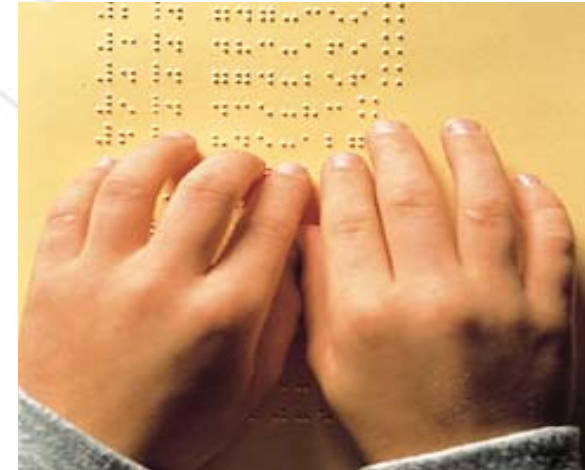
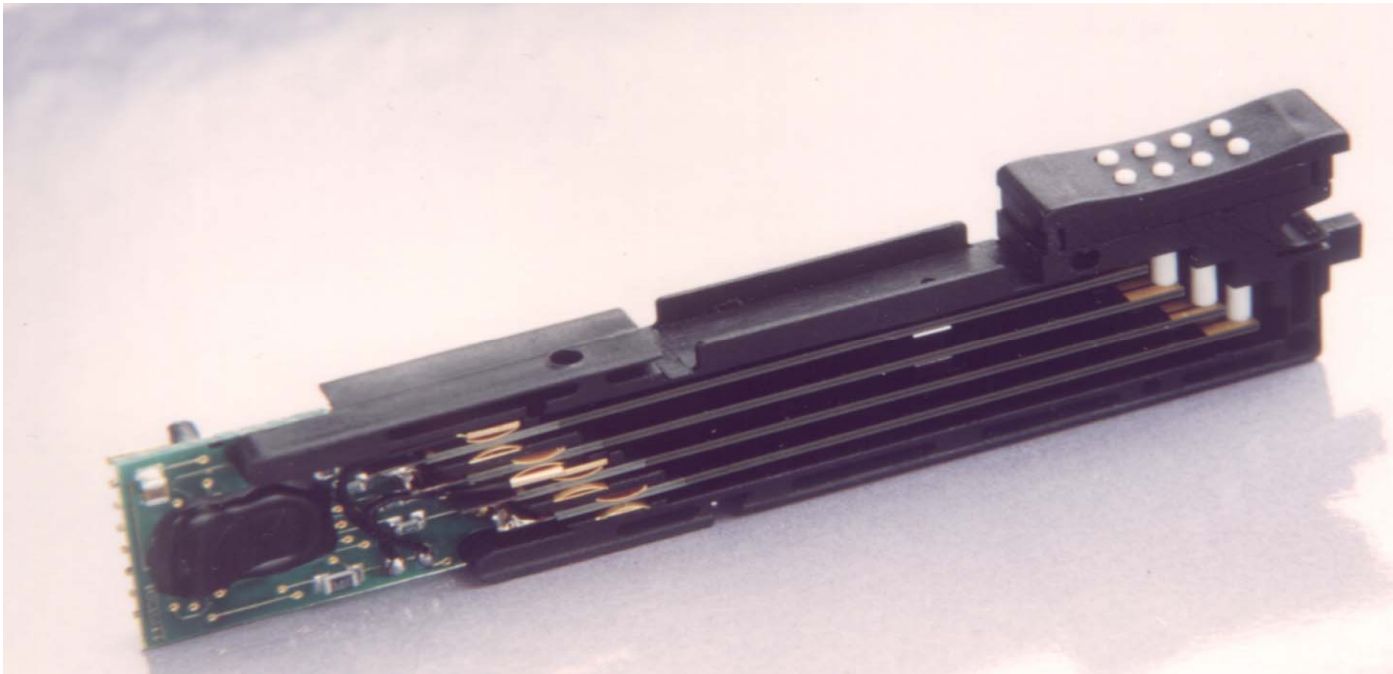


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Piezo braille module for controller keyboards

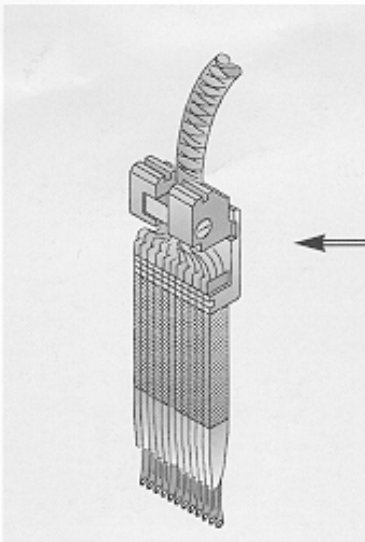
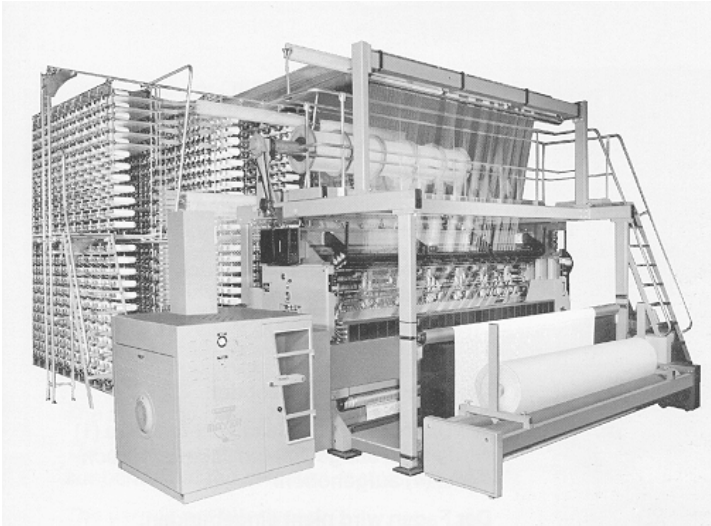


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Bending actuator for warp knitting machines

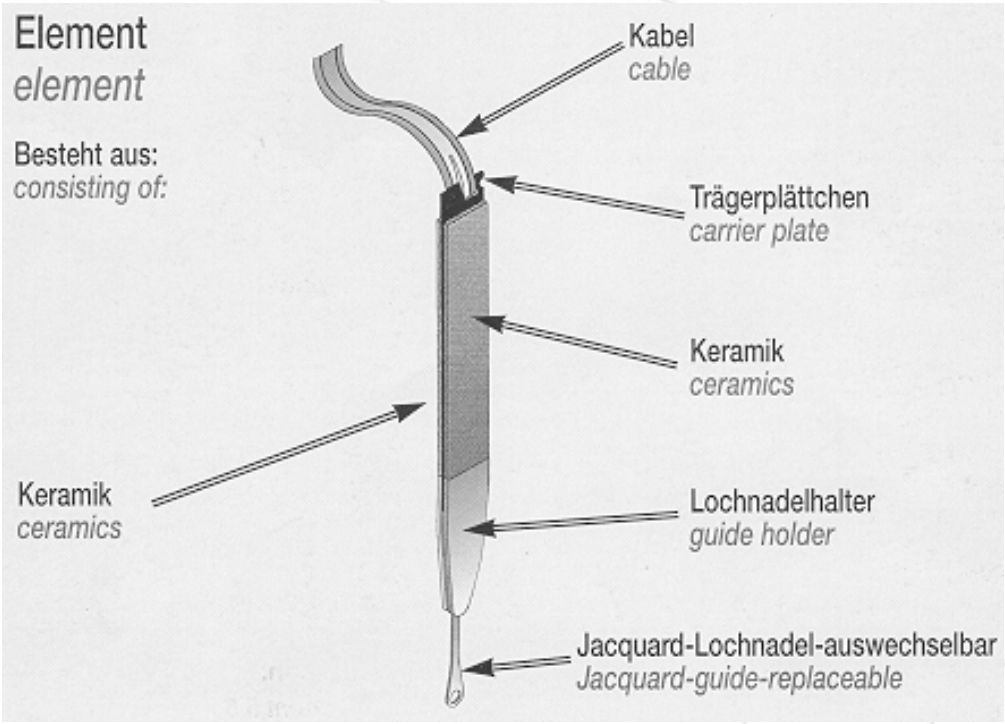


Jacquardsegment
Jacquard segment

Besteht aus 16 bzw. 32 Elementen.
Consisting of 16 and / or 32 elements.

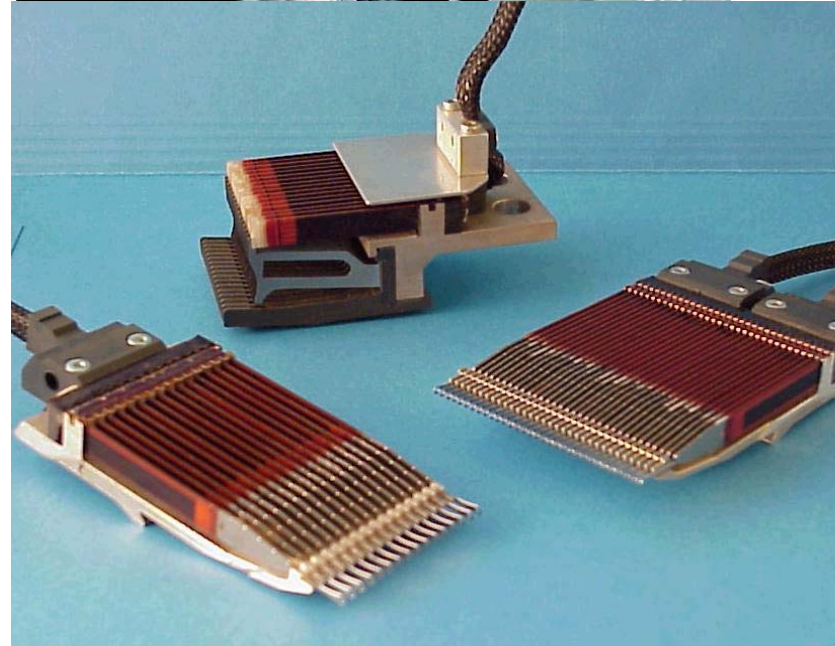
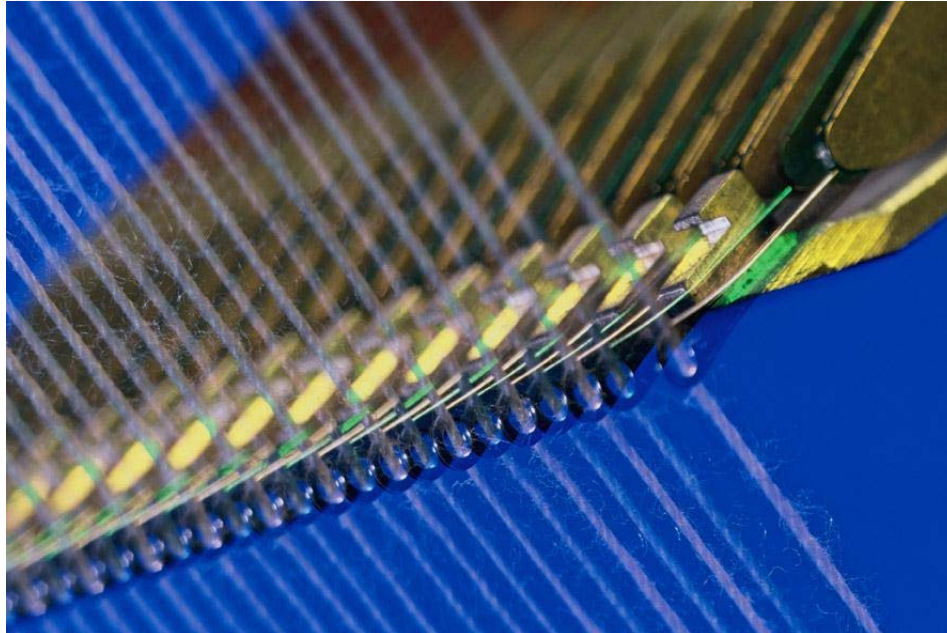
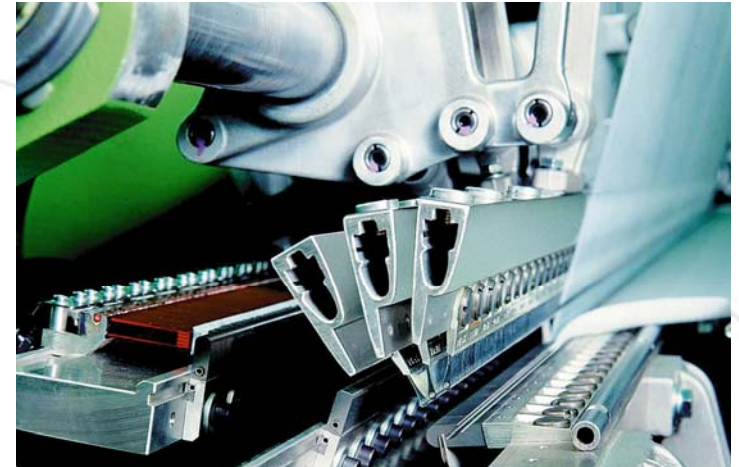
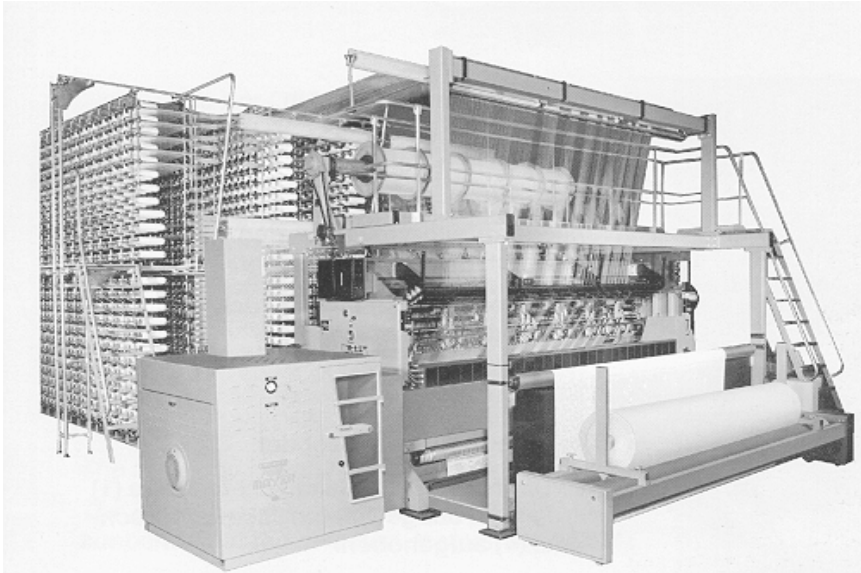
Element
element

Besteht aus:
consisting of:



Textile machine module for warp knitting machines

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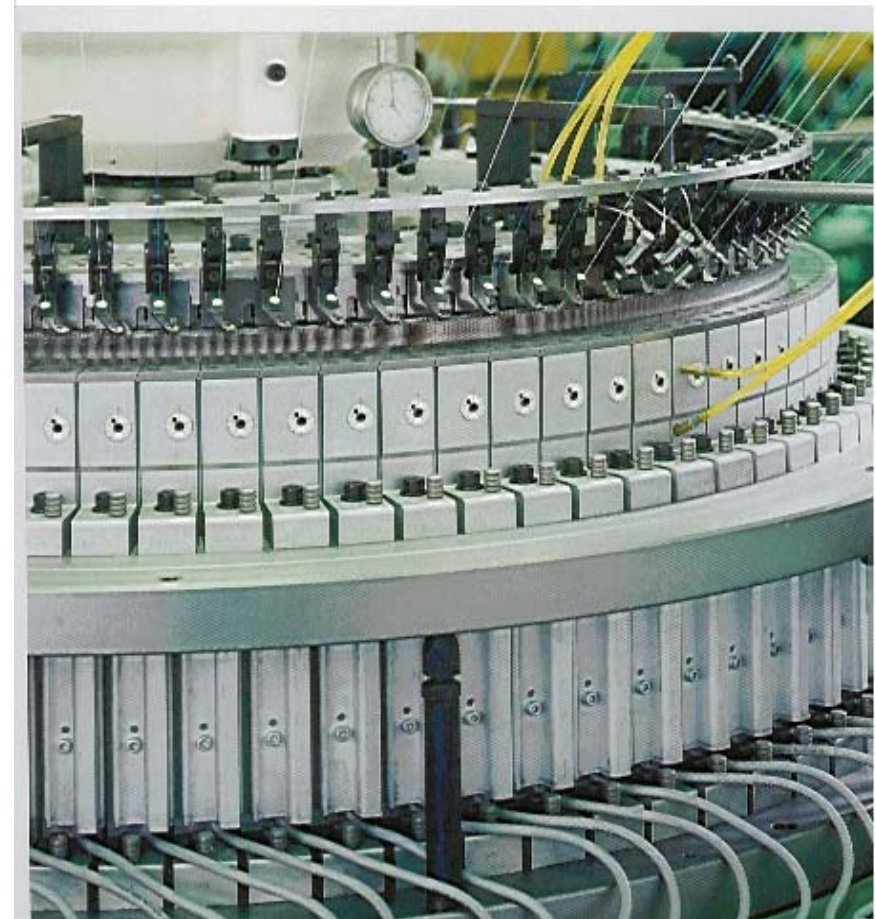
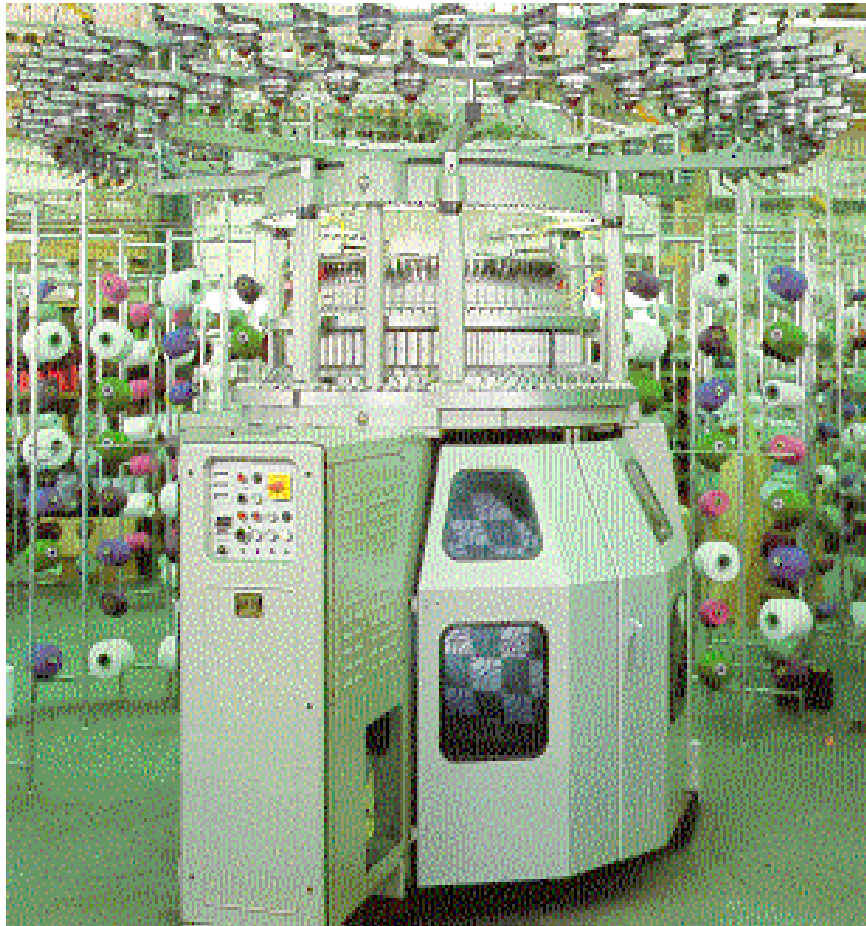
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SITEX[®] M - Textile machine module for circular knitting machines

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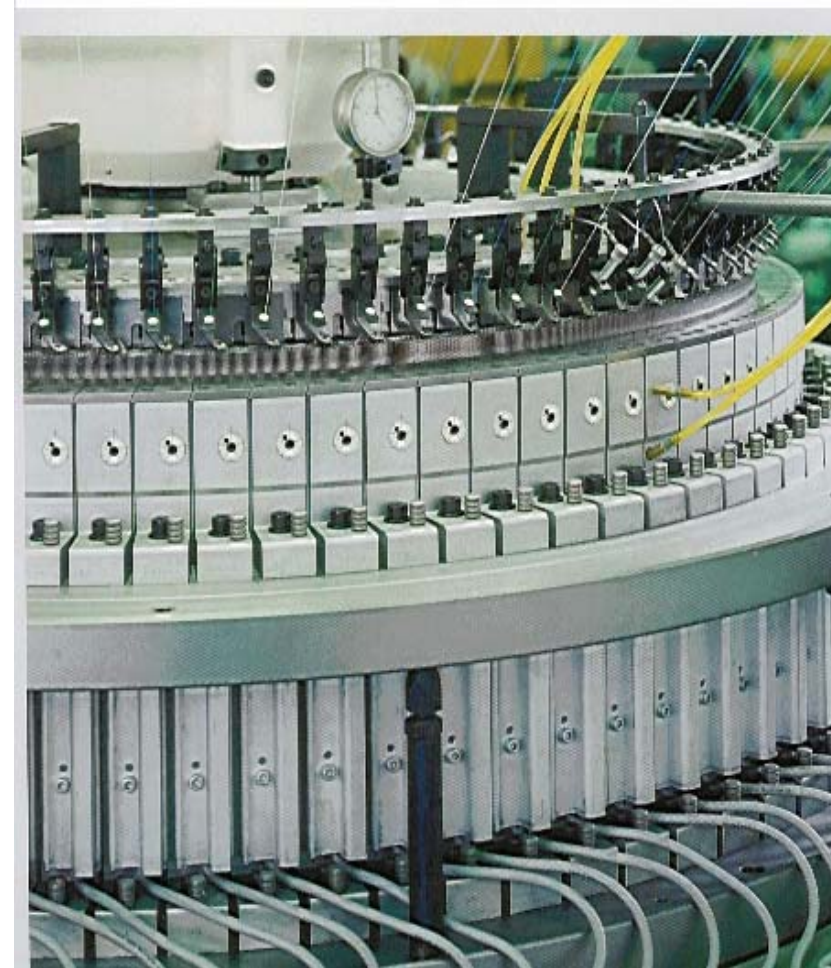
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SITEX[®] M - Textile machine module for circular knitting machines

Circular knitting machines

SITEX M - Textile machine module

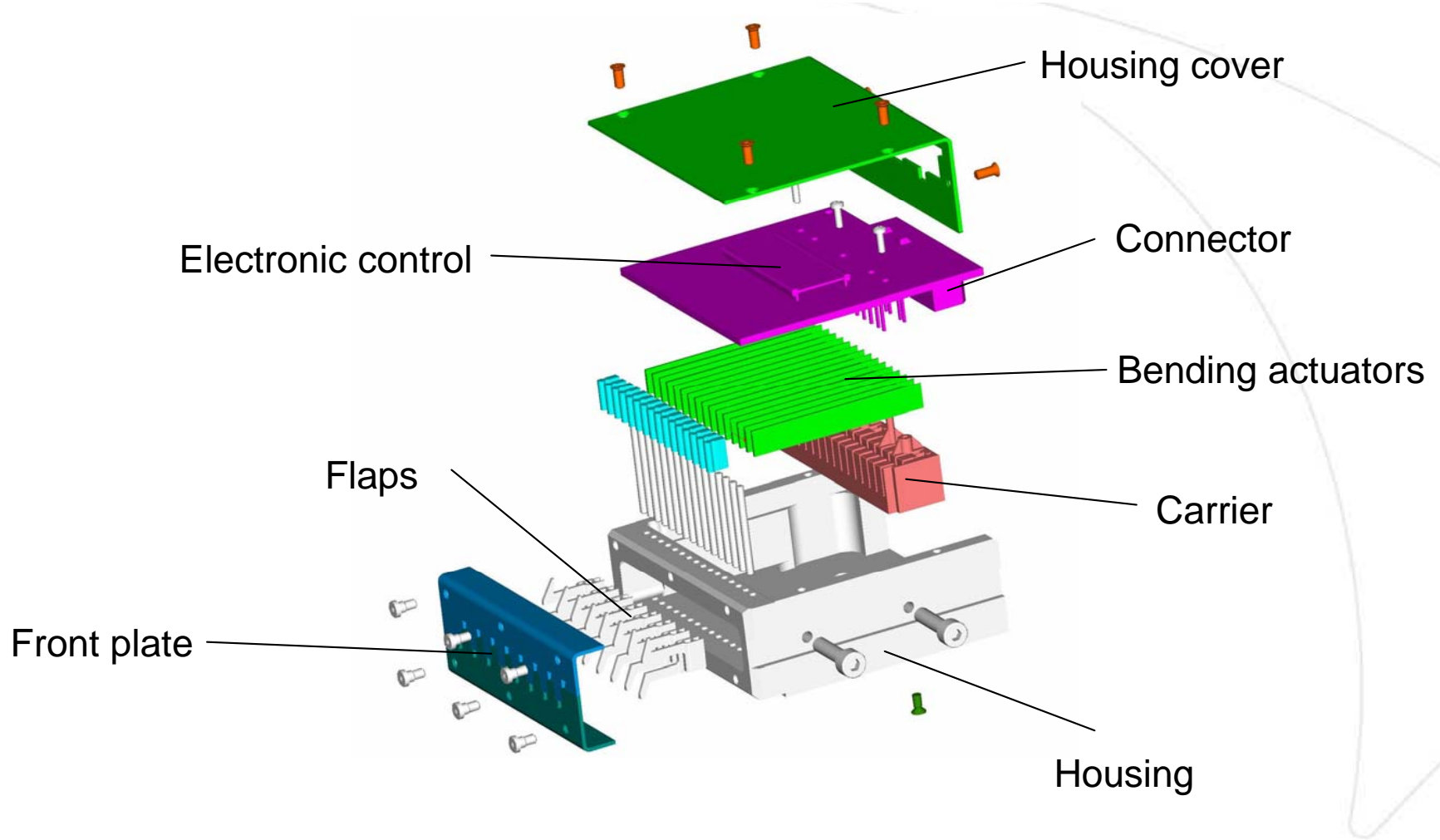


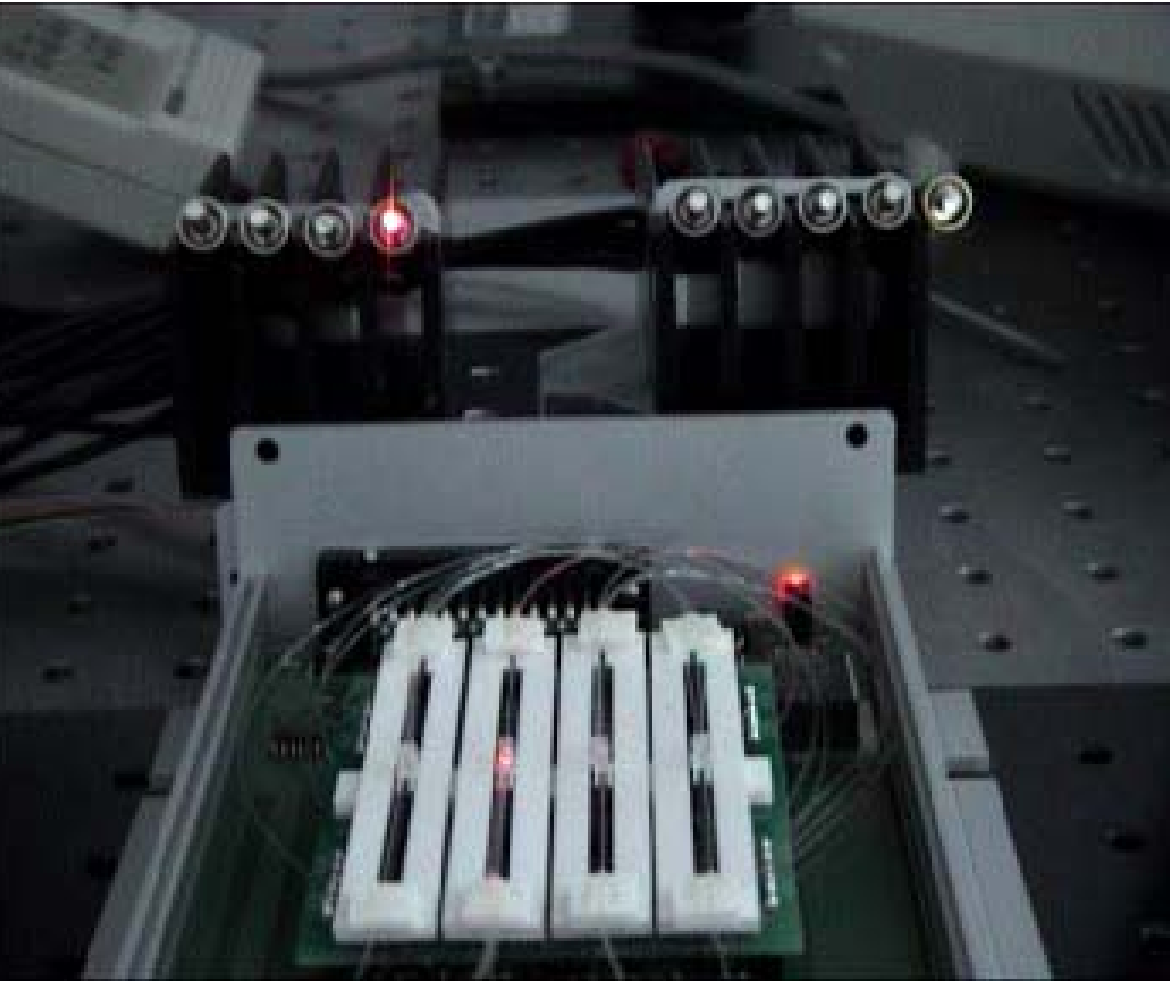
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SITEX[®] M - Textile machine module for circular knitting machines





Advantages:

- fast switching time
- low insertion loss
- high optical isolation
- compact design
- no additional wavelength dependence

Applications:

- optical measurement systems
- spectroscopy
- optical engineering
- telecommunications

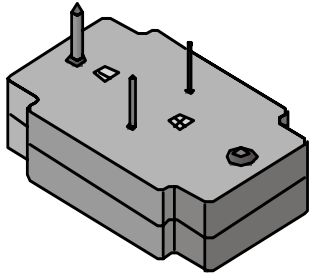


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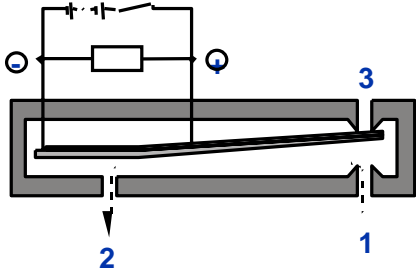
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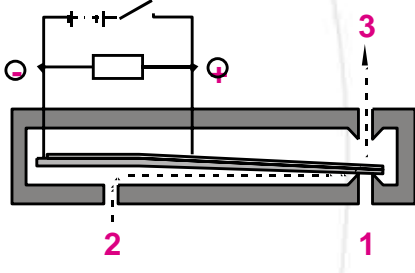
High - dynamic pressure regulator



Flap On



Flap Off

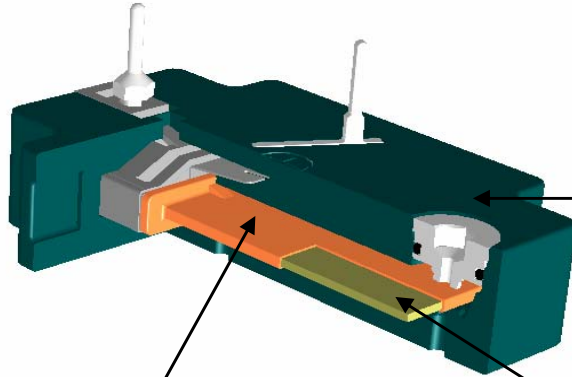


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The new generation of piezoelectric valves



Plastic Housing

- + higher precision
- + lower weight
- + cheaper

Elastomere enclosure

- + improved sealing
- + protection against humidity
- + separates medium from electric terminals

Bender

- + „power free“ control
- + nearly no wear
- + ideal for intrinsic safety
- + works digital and analog
- + no self heating
- + no electromagnetic load
- + antimagnetic



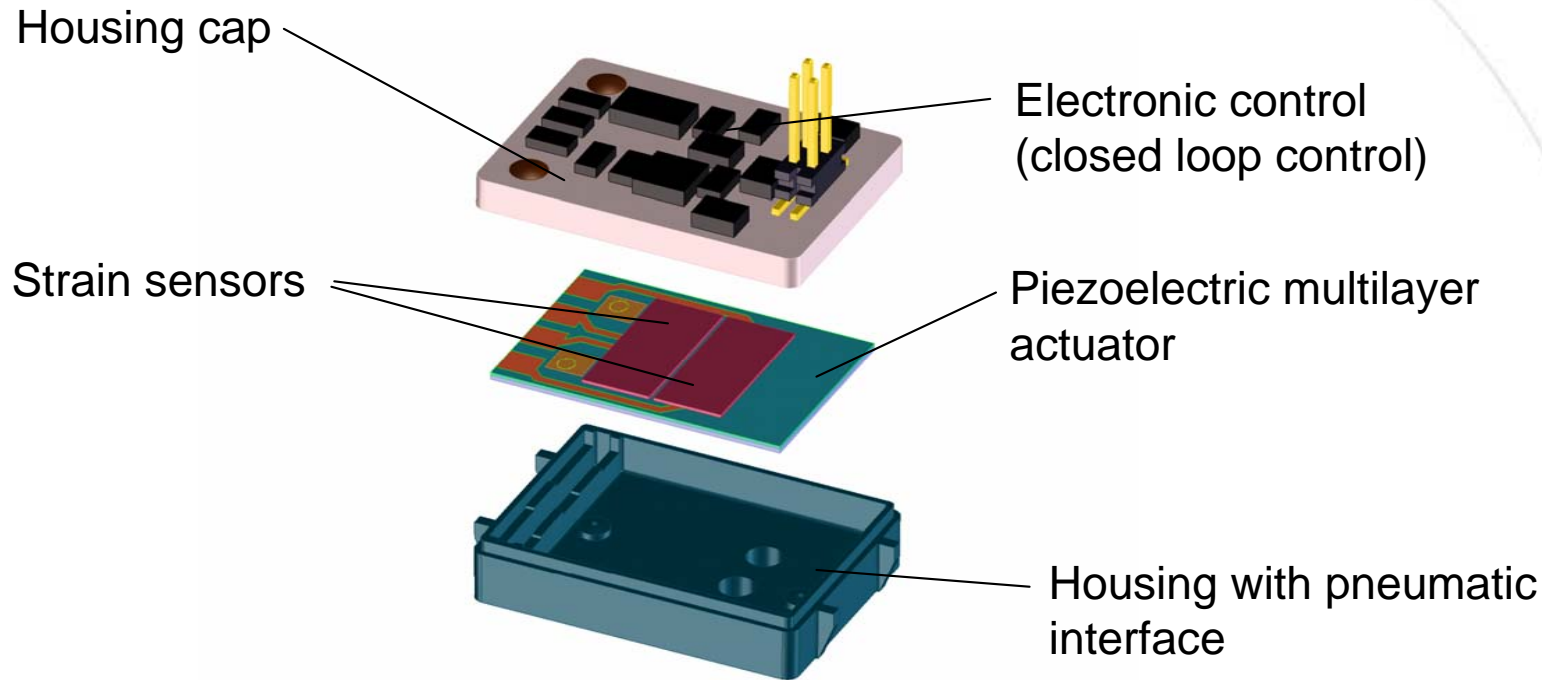
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3/2 normally-closed piezoelectric micro valve

Concept of a polymer micro valve with an piezoelectric multilayer actuator and an polymer strain sensor

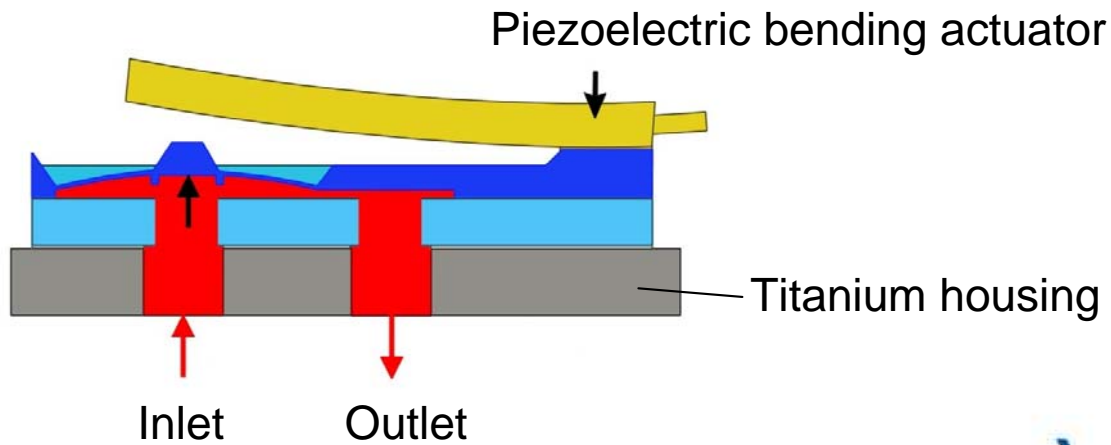
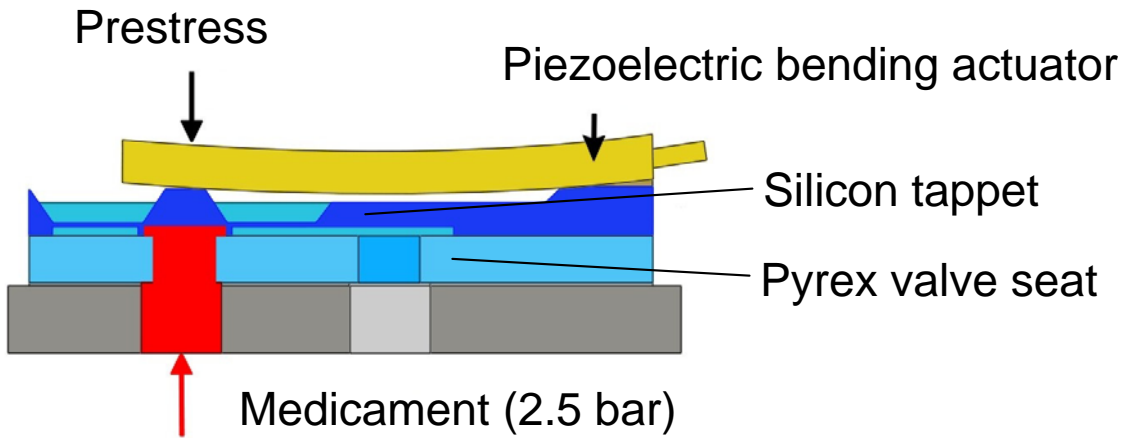


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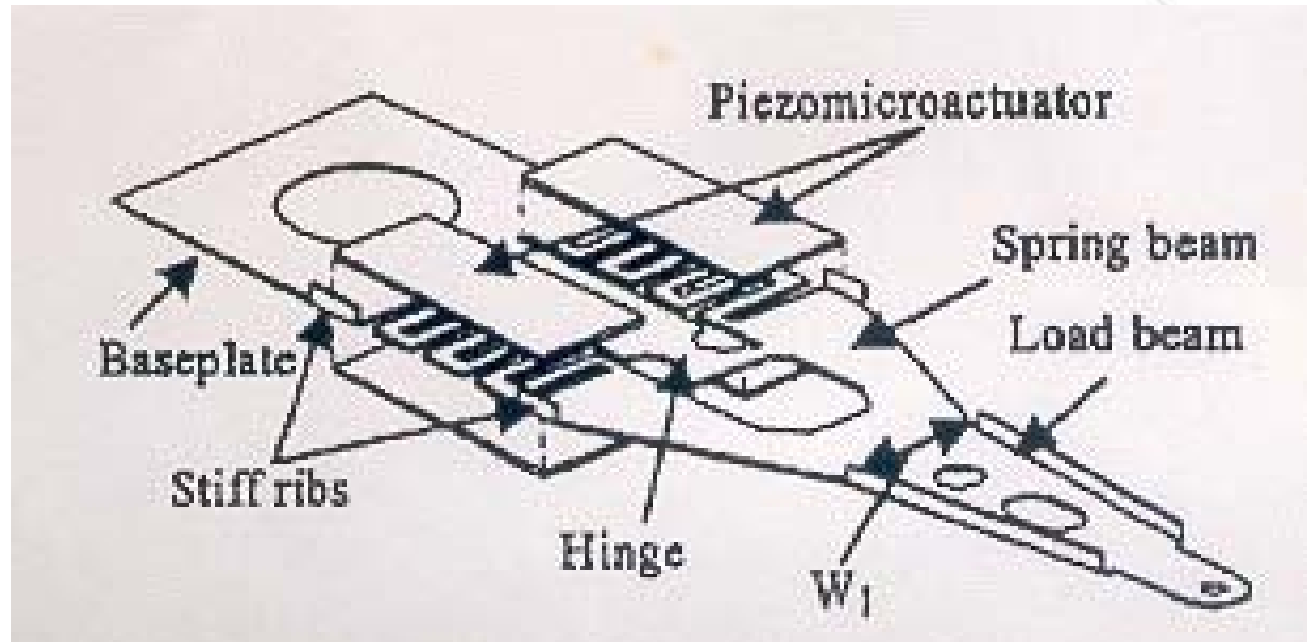
Micro valves for implantable microdosage systems



Piezoproducts

Piezoelectric actuated suspension for hard disk drives

Piezoelectric micro actuators for the positioning of write-read heads.



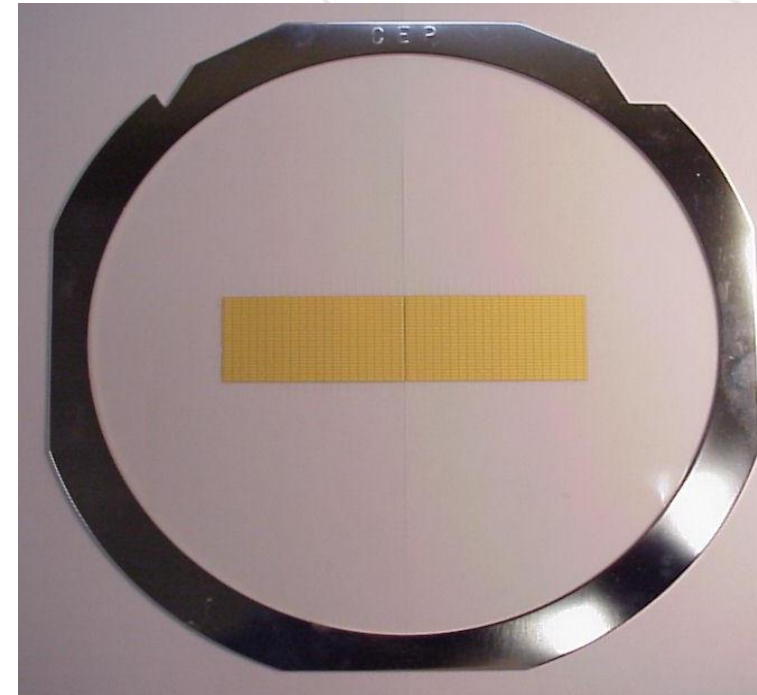
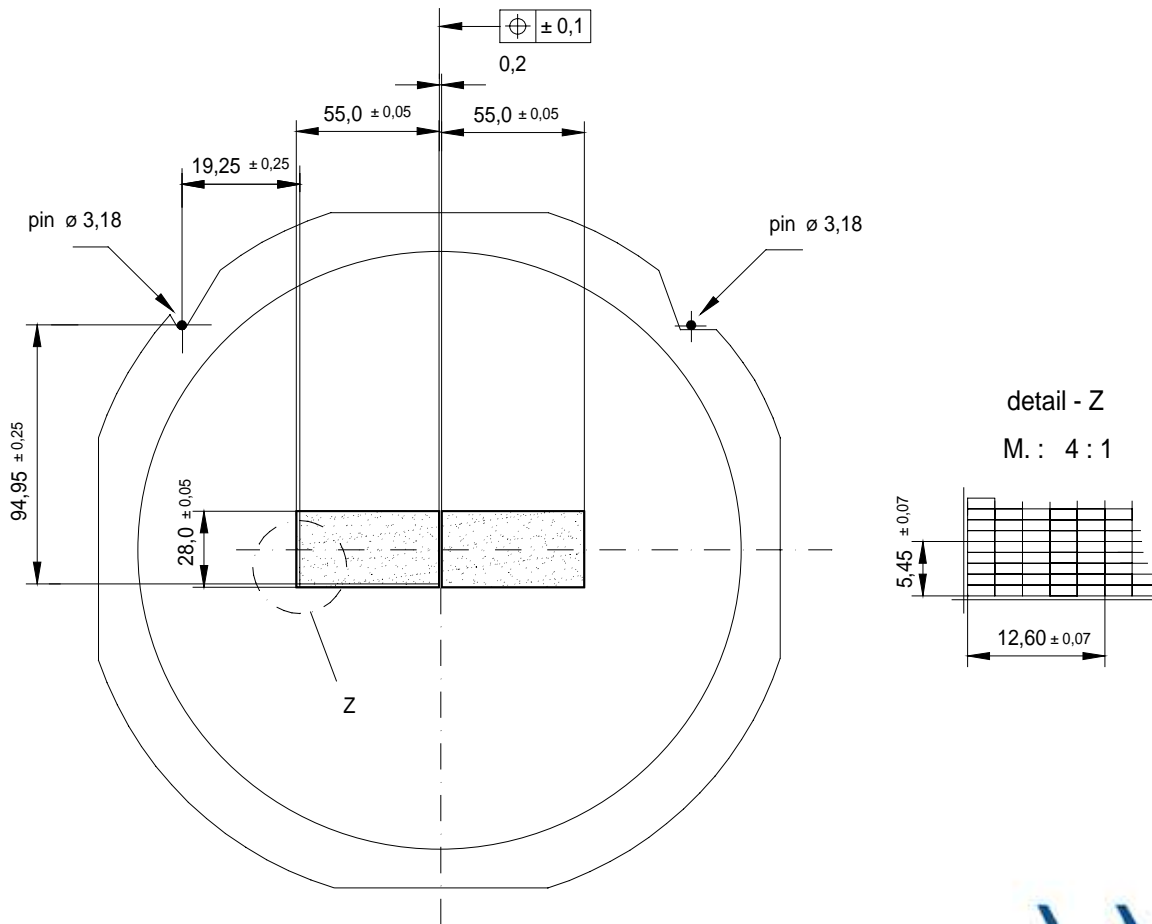
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Piezoelectric micro actuators

Piezoelectric micro actuators for the positioning of write-read heads.
Applications: tape drives, hard disk drives, DVD- and CD-writer



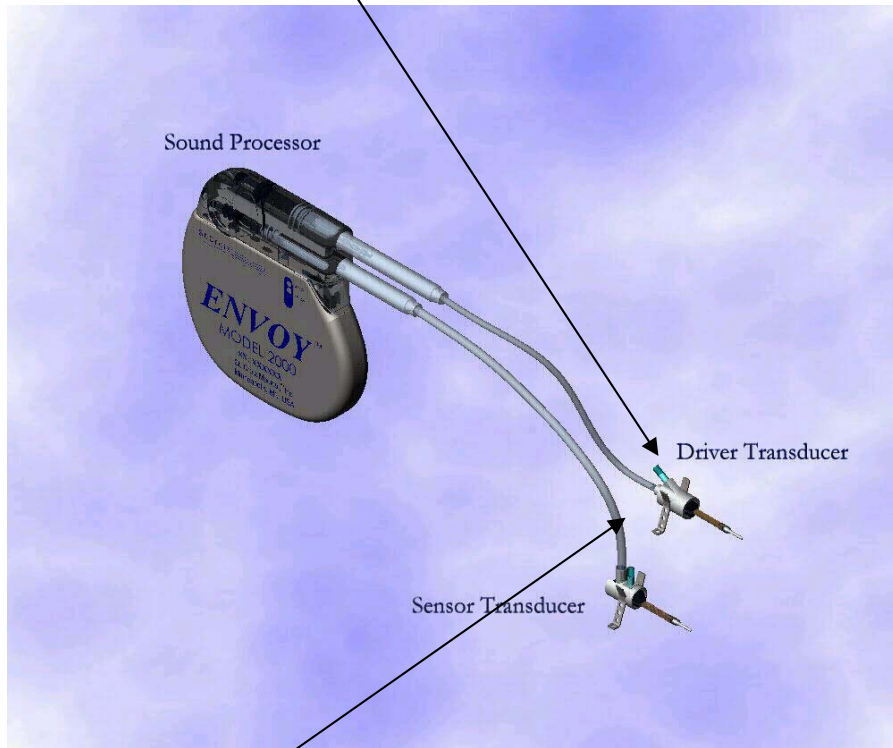
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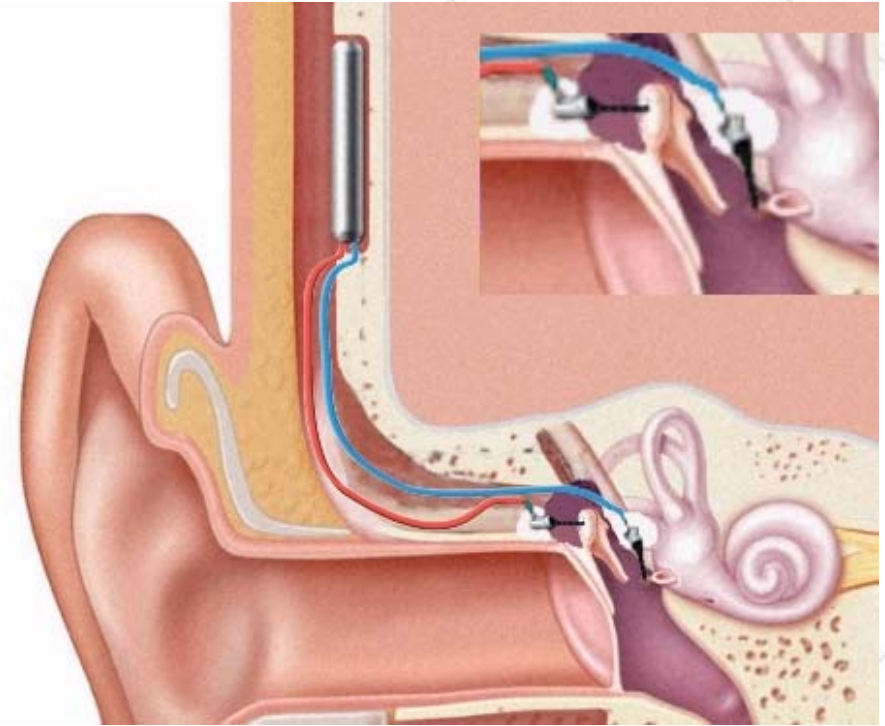
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Piezoceramic bending actuator and sensor for implantable hearing aids

The **PZT Driver** converts the amplified electrical signal received from the Sensor (via the **Sound Processor**) into mechanical vibration to drive the stapes.



The **PZT Sensor** fulfills the role of a microphone in a conventional air conduction hearing aid.



More info at: www.stcroixmedical.com



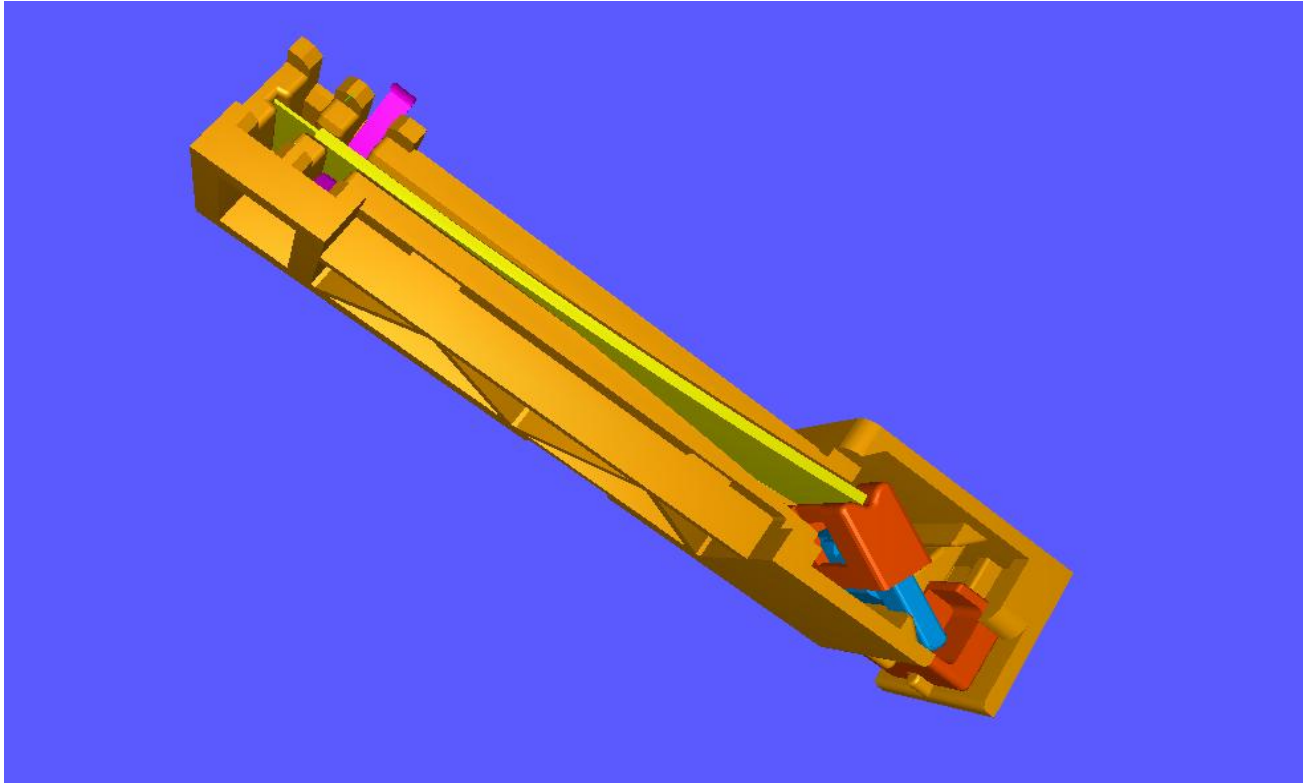
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EnOcean - Piezoceramic generators

Conversion of mechanical energy into electrical energy.



Applications:

Light switch
Tire guard

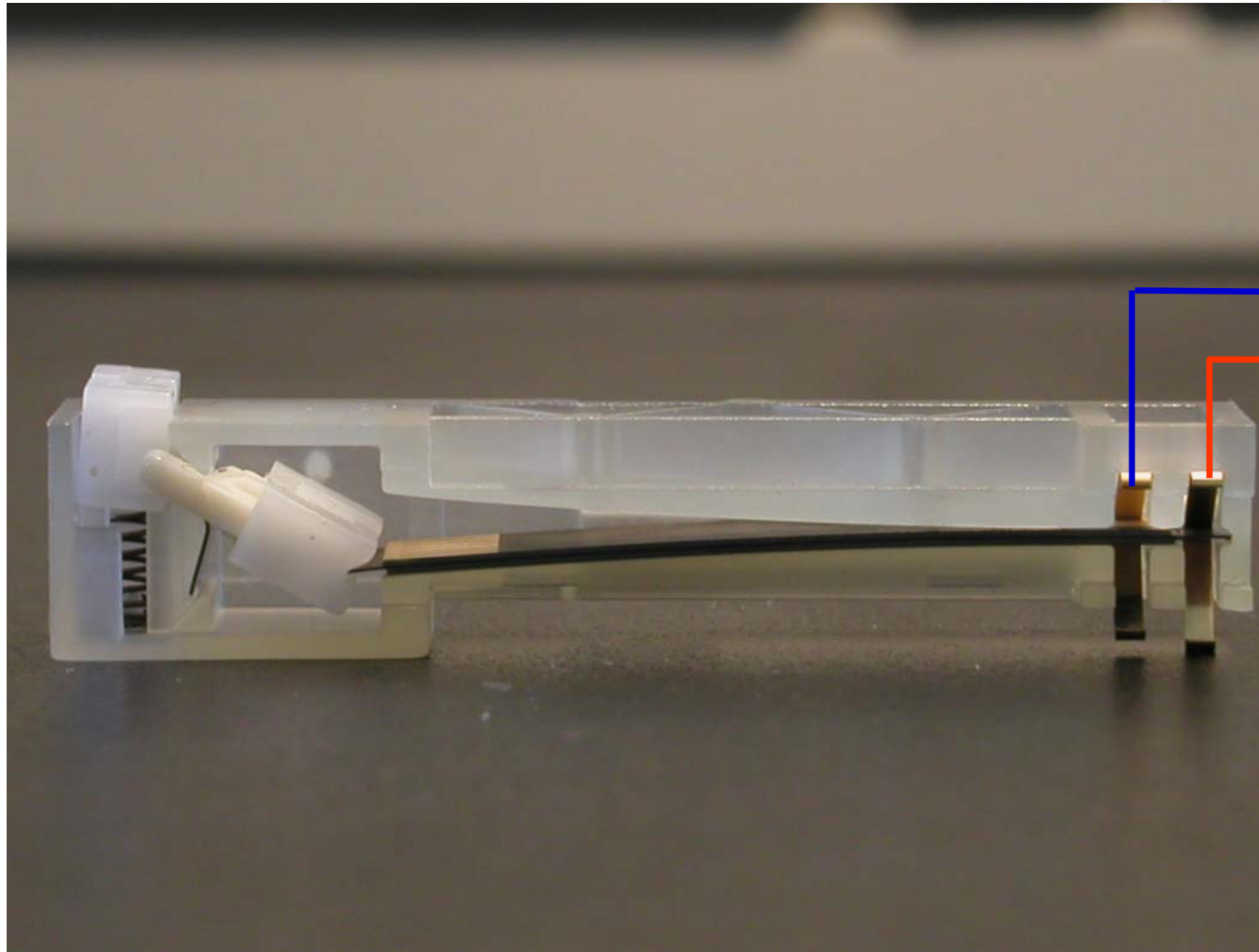


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Piezoceramic bending actuator for radio switches



Energy generator
for the radio switch

Energy per
one actuation
= 25 μ Ws



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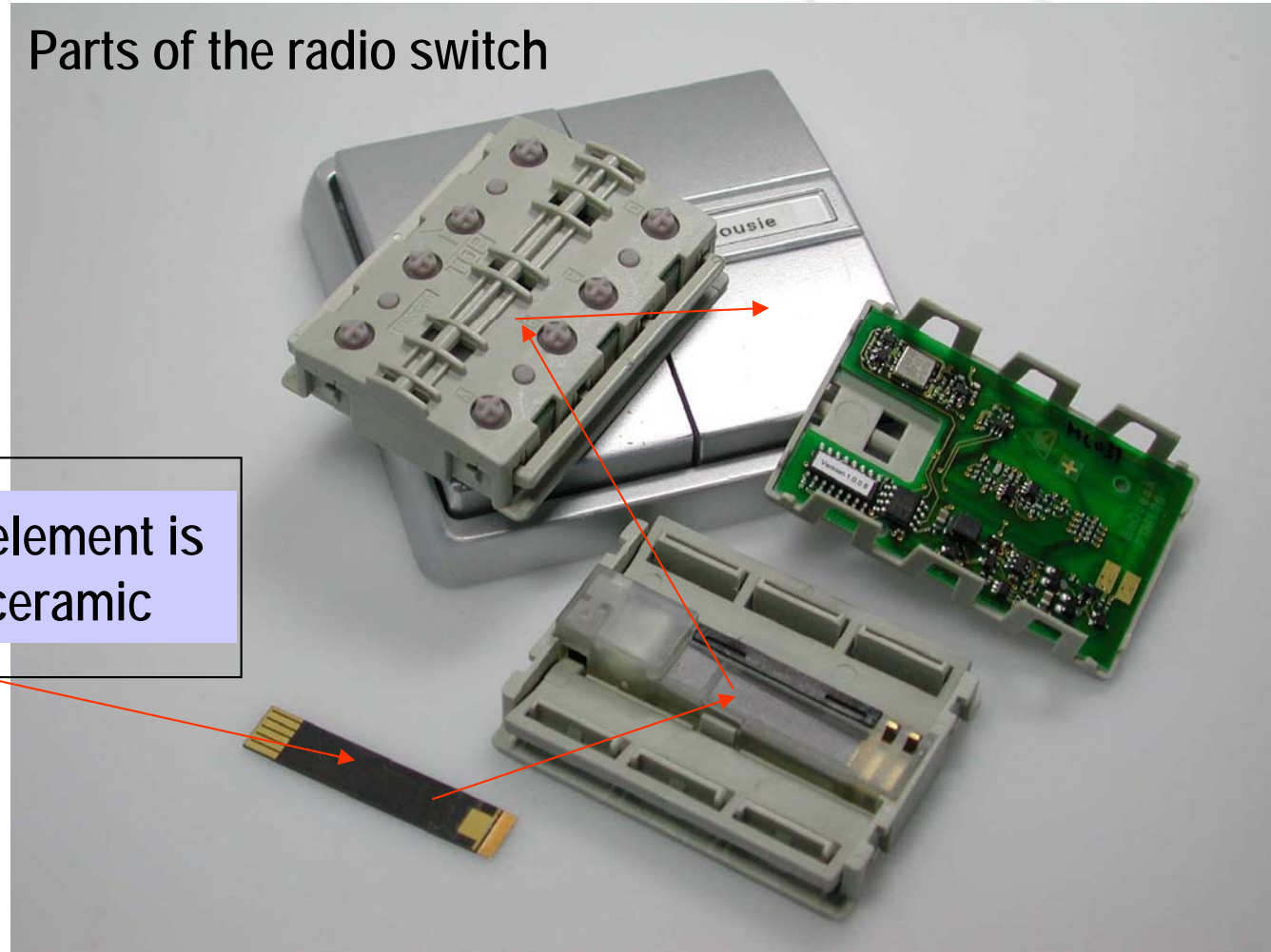
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Piezoceramic Bending Actuator for radio switches

Parts of the radio switch

The core element is
the Piezoceramic



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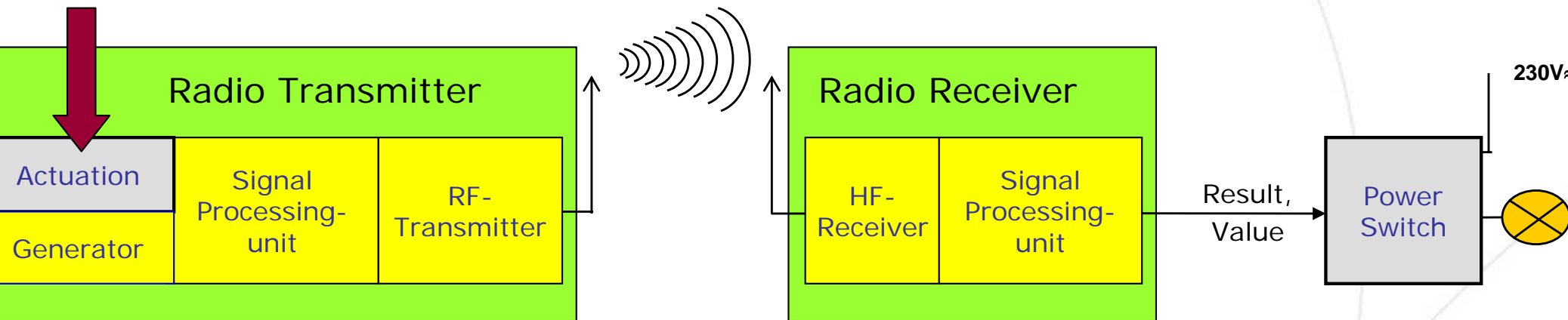
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EnOcean - Piezoceramic bending actuator for radio switches

Batteryless radio switch

Conversion of mechanical energy into electrical energy

Transmitting of signals and information



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Building

Industry

Automotive

Medical



Radio switches

- Installation
- Renovation

Radio sensors

- Control Sensors
- Position Indicator Switch
- Monitoring

Radio switches

- Keyless entry
- Tire Guard

Micro Radio Generators

- Control of the human body functions



Piezoproducts

Benefits of piezoelectric bending actuators

- Rapid positioning speed results in significantly increased productivity.
- High reliability dramatically reduces outage times.
- The bending actuator produces no heat, therefore no cooling is required.
- Energy consumption is noticeable low as with the magnet that results in reduced operating costs.
- The compact construction means that the bending actuator requires significantly less space.
- Silent operation provides for the most ergonomic possible workplace.
- The bending actuator can be modified for specific applications.



Conclusion

Overview on the Application of Piezoceramics Bending Actuators

- Electromechanical transformer (actuator/sensor/generator)
- All-purpose usable. Usable in nearly all markets
- High increasing market rates

Piezoproducts

- Basic Materials
- Bending Elements
- Modules & Devices



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References

- [1] M. Laurent, H. Bödinger, T. Steinkopff, K. Lubitz, C. Schuh, S. Wagner, M. J. Hoffmann, H. Murmann-Biesenecker, A. J. Schmid, "Influence of ceramic layer thickness on the properties of piezoelectric multilayer actuators", Processing of Electroceramics, Symposium 2003, (2003)
- [2] U. Dibbern: Piezoelectric Actuators in Multilayer Technique. Proceedings of Actuator 94, (1994)
- [3] B. Anderson: Properties and Performance of Multilayer Actuators for Dynamic Applications. Proceedings of Actuator 1996, (1996)
- [4] A. J. Schmid, U. Töpfer, R. Ballas, H. F. Schlaak, G. Munz, M. Maichl, A. Münzenmaier, "Piezoelectric Beam Multilayer Actuator with an Integrated Capacitive Strain Sensor to Detect Deflection", Sensor 2003, (2003)
- [5] M. Weinmann, M. Maichl, G. Munz, C. Hanisch, H. P. Post, "A 3/2 Normally Closed Polymer Piezoelectric Microvalve with Integrated MID Electronics for Industrial Automation"; Actuator 2002, (2002)
- [6] Y. Nui, W. Guo, G. Guo, E. Hong, T. Huang, "Piezoelectrically Actuated Suspension for Hard Disk Drives Storage", Proc. Syst., Vol. 1.; 321 -327, (1999)
- [7] A. J. Schmid, U. Töpfer, "Smart Piezoelectric Multilayer Actuator with an Integrated Sensor to Compensate External Loads", Adaptronic Congress 2003, (2003)
- [8] A. J. Schmid, „Piezokeramische Systeme – Physikalische Eigenschaften und Anwendungen“, Technische Keramik in der Praxis, Verband der keramischen Industrie e.V., Selb, (2002)
- [9] C. Schuh, K. Lubitz, Th. Steinkopff, A. Wolff, "Piezo electric Components for Technical Applications", Piezoelectric Materials, Ed.: C. Galassi et al., Kluwer Academic Publ. 2000, 391- 399, (2000)
- [10] A. J. Schmid, "Smarter Niedervoltaktor – Multilayer Biege wandler mit integrierter Sensorik", Deutsche Keramische Gesellschaft, 10. Keramik-Tag der Bundesanstalt für Materialforschung, Symposium: Folien und Multilayertechnologie für funktionskeramische Anwendungen, (2003)



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