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
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)$^{4+}$

Piezoproducts

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Piezoelectric effect - Curie temperature

Perovskite Crystal Structure

PZT Cubic crystal
($T > T_c$)

- $\text{Pb}^{2+}$
- $\text{O}^{2-}$
- $X^{4+}$ (Ti, Zr)

PZT Tetragonal crystal
($T < T_c$, Spontaneous Polarisation)
**Piezoelectric effect**

Piezoelectric effect

Conversion of a mechanical stress into an electrical signal.

Inverse piezoelectric effect

Mechanical output produced by an electrical input.
Bending actuator structure techniques

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**Bending actuator**

Deflection of a trimorph bending actuator

- Contraction of the ceramic by applying the operating voltage
- Results in deflection of the bending actuator
Bending actuator

Deflection of a trimorph bending actuator

Contraction of the ceramic by applying the operating voltage

Results in deflection of the bending actuator
Bending actuator - force-deflection characteristic

Blocking Force $F_0$ [mN]

Deflection $\xi$ [mm]

max. deflection $\xi_0$

possible operating point

blocking force $F_0$

bending energy
Bending actuator - force-deflection characteristic

monomorph bending actuator

<table>
<thead>
<tr>
<th>ceramic</th>
<th>h₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>passiv layer</td>
<td>h₂</td>
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a) maximum deflection $\xi_0$

$$\xi_0 = \frac{3}{4} d_{31} U \left( \frac{l^2}{h_1^2} \right) f_E$$

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

a) blocking force $F_0$

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

$$f_m = \frac{a c (1 + a)}{2 (1 + a c)}$$
performance index = blocking force \times \text{max. deflection}

Bending actuator - Performance index

- **Steel**
- **Aluminium**
- **Carbon fibre**

performance index vs. thickness proportion $a$
Piezoproducts - Portfolio

Basic Materials
- Actuators / Sensors
  - Piezo Masses
  - Ceramics
    - Discs
    - Plates
    - Rings
    - Tubes
    - Special geometries

Bending Elements
- Actuators
  - Bending actuators
    - Singlelayer
      - Braille modules
      - Textile machines
      - Hard disks drives
      - Valves
      - Gas flow controls
      - Switcher
      - Textile machines
      - Hard disks drives
      - Valves
      - Gas flow controls
      - Automotive applications

- Sensors
  - Bending actuators
    - Medical engineering
    - Other applications
  - Ultrasonic transducer
    - Flow measurement
    - Other applications

- Modules & Devices
  - Actuators
    - Pattering modules
      - Jacquard machines
      - Raschel machines
      - Warp Knitting machines
    - SITEX M-Module
      - Circular Knitting machines
    - Ultrasonic atomizers
      - Refrigerated cabinets
      - Home appliances
      - Toys
      - Inhalers for lung diseases
      - Humidifier
    - Valves applications
      - Glue valves
      - Air pulse valves
      - Air sort valves
      - Door shuts
      - Hydraulic systems
  - Sensors
    - Ultrasonic systems
      - Tank level measuring

Piezoproducts
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Divided into three groups

Basic Materials

Bending Elements

Modules & Devices

Piezoproducts

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Multilayer bending actuator

Design of a monomorph multilayer bending actuator with thermal tension adjustment

- Multilayer ceramic
- Inner electrodes
- Conntact
- Passive layer
- Copper contact pads
- Thermal tension layer
Piezo braille module for controller keyboards
Bending actuator for warp knitting machines

Jacquardssegment
Jacquard segment

Element
Element

Kabel
cable

Trägerplättchen
carrier plate

Keramik
 ceramics

Lochnadelhalter
guide holder

Jacquard-Lochnadel-auswechselbar
Jacquard-guide-replaceable

Piezoproducts

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Textile machine module for warp knitting machines
SITEX ® M - Textile machine module for circular knitting machines
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Circular knitting machines

SITEX M - Textile machine module

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Piezoproducts
Piezoceramic bending actuator for fiber optical switches

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

Applications:
- optical measurement systems
- spectroscopy
- optical engineering
- telecommunications
High - dynamic pressure regulator

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The new generation of piezoelectric valves

Plastic Housing
- higher precision
- lower weight
- cheaper

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

Elastomere enclosure
- improved sealing
- protection against humidity
- separates medium from electric terminals
3/2 normally-closed piezoelectric micro valve

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

- Housing cap
- Electronic control (closed loop control)
- Strain sensors
- Piezoelectric multilayer actuator
- Housing with pneumatic interface
Micro valves for implantable microdosage systems

Prestress

Piezoelectric bending actuator

Silicon tappet

Pyrex valve seat

Medicament (2.5 bar)

Titanium housing

Inlet

Outlet

Piezoelectric bending actuator

Piezoproducts
Piezoelectric actuated suspension for hard disk drives

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


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**Piezproducts**

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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](http://www.stcroixmedical.com)
EnOcean - Piezoceramic generators

Conversion of mechanical energy into electrical energy.

Applications:
Light switch
Tire guard
Piezoceramic bending actuator for radio switches

Energy generator for the radio switch

Energy per one actuation

= 25 µWs
Piezoceramic Bending Actuator for radio switches

The core element is the Piezoceramic

Parts of the radio switch
**EnOcean - Piezoceramic bending actuator for radio switches**

Batteryless radio switch
Conversion of mechanical energy into electrical energy
Transmitting of signals and information
EnOcean - Piezoceramic Generators

Radio sensors
- Control Sensors
- Position Indicator Switch
- Monitoring

Radio switches
- Keyless entry
- Tire Guard

Micro Radio Generators
- Control of the human body functions

Building
- Radio switches
  - Installation
  - Renovation

Industry
- Radio sensors

Automotive
- Radio switches
- Keyless entry
- Tire Guard

Medical
- Radio switches

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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 noticeably 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
References