Fraunhofer ISC

FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC

1 *Piezoelectric thin film ultrasonic transducer array*
© Fraunhofer ISC

PIEZOELECTRIC THIN FILM TRANSDUCERS

Motivation

PZT (abbreviation for $Pb(Zr,Ti)O_3$) thin films on metallic substrates can be widely used as piezoelectric sensors and actuator elements (e.g. micromotors, electric transformers and acoustic transducers). Due to low fabrication costs and an easy integrability into small-size electromechanical devices, the combination of piezoelectric thin films and metal substrates has many advantages.

The ISC approach

The preparation of PZT thin films on metallic substrates is based on the idea of combining the piezoelectric (i. e. sensor and actuator) properties with widely used, low-cost substrates. PZT thin films were prepared by a modified sol-gel process using annealing temperatures of 600 °C for 5 minutes (see patent no. DE 19744630 C1).

After processing the single film thickness on a metal substrate was 0.8 µm. To achieve a higher film thickness of up to 6 µm the coating procedure was repeated. The sub-strate thickness was between 0.01 mm and 0.2 mm, the maximum size was limited by the furnace used (about 100 x 200 mm^2). Gold electrodes were sputtered onto the film as top electrodes.

The diagram overleaf shows the fatigue of the charge generation. A cyclic mechanical stress was applied to the PZT thin films by bending the samples with a frequency of 2 Hz at room temperature. The maximum strain applied was 0.12 percent. The measurements show a nearly constant charge generation up to 400 nC/cm^2 for more than 10^7 mechanical cycles.

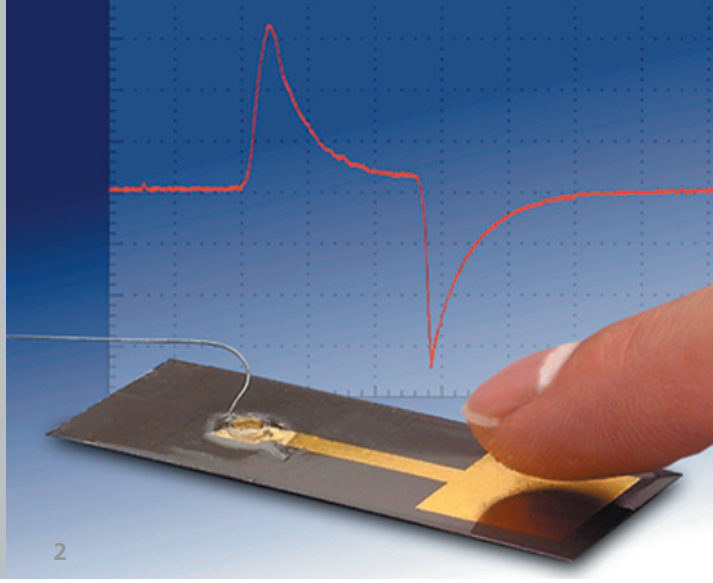
Piezoelectric thin films are applicable to high-power air-coupled ultrasonic transducers (see Figure 1, Page 1) for non-destructive testing without liquid coupling

Fraunhofer-Institut für Silicatforschung ISC
Neunerplatz 2
97082 Würzburg, Germany

Contact
Center Smart Materials CeSMa

Dr. Bernhard Brunner
Phone +49 931 4100-416
bernhard.brunner@isc.fraunhofer.de

www.isc.fraunhofer.de



media and to parametric laudspeaker systems for the emission of highly-directional sound. The frequency range available is 30 – 200 kHz. By subdividing the transducer electrode, structure arrays for electronic beam steering are realizable.

Customer benefit

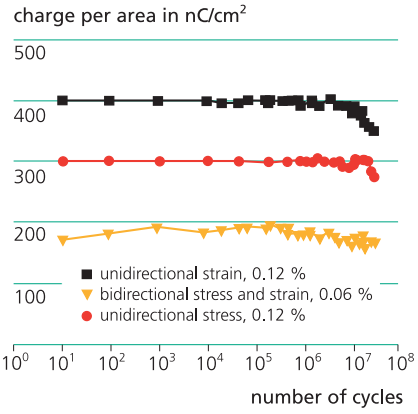
The advantages of piezoelectric thin films:

- frequency response from 0.1 Hz to 200 kHz
- temperature range from -40 °C to 150 °C
- fabrication in large areas, i. e. low cost for a single small sensor element or the production of large sensor elements
- easily mouldable and to be mounted
- high remanent polarization of 30 µC/cm²
- applied voltage lower than 30 V for the excitation of an actuator element
- mechanical stability up to 10^7 cycles at 0.1 percent strain on commercial steel substrates
- simple electrical contact
- high dielectric permittivity ($\varepsilon_{33} \approx 400$),
- piezoelectric modulus of 60 pC/N

The potential for future applications includes piezoelectric sensors (Figure 2) and actuator elements (Figure 1), e.g in the following areas:

- machine-tool industry
- aviation
- automotive engineering
- medical technology
- non-destructive testing
- security systems
- microscopy
- mechatronics
- micromachining

Years of expertise in the preparation and testing of PZT thin films especially developed for research or prototype production and small series allow to respond quickly and accurately to customers requests.



Piezoelectric charge of PZT thin films as a function of the number of mechanical bending cycles

1 *Integrated thin-film piezoelectric cantilever of 50 mm in length at the first resonance frequency of 37 Hz*

2 *A piezoelectric thin-film sensor*