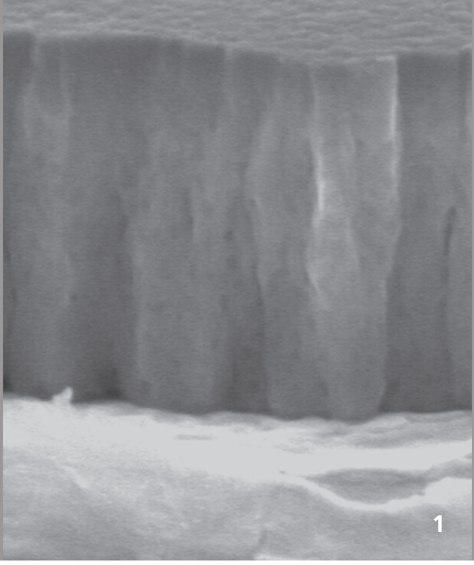

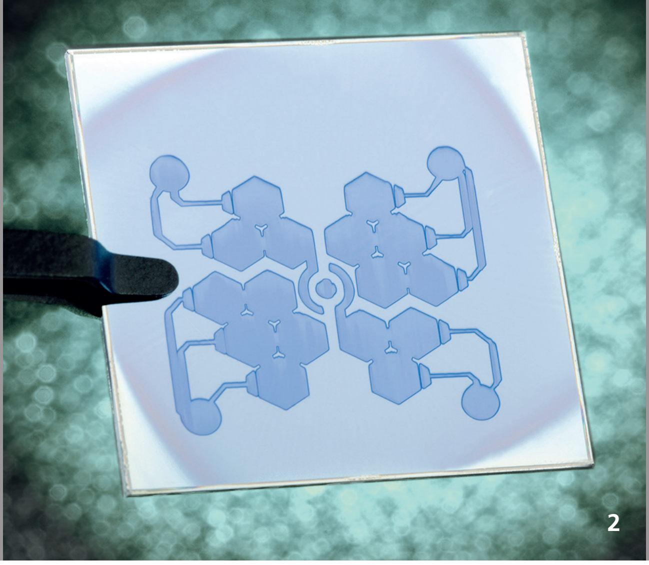

Subject to alterations in specifications and other technical information. 08/2018.

ADDITIVE, LASER-BASED MANUFACTURE OF PIEZOELECTRIC LAYERS

Task

In the course of miniaturization and the increasing integration of electrical circuits, microelectromechanical systems (MEMS) continue to become more important. Piezoelectric materials are used for microactuators; these materials mechanically deform when an electric field is applied. Sol-gel-based systems out of lead zirconate titanate (PZT) are characterized by their pronounced dielectric and piezoelectric properties with thinly applicable layer thicknesses, but have to be crystallized by means of thermal post-treatment. In contrast to conventional furnace processes, laser processes can heat small volumes for a short period of time in a location-selective manner, thus reducing the thermal impact on the coated substrate.

Method

Sol-gel-based PZT precursor solutions are spin-coated onto specially prepared silicon wafers. Subsequently, in a laser-based process, the organic components are removed (pyrolysis) and the layers crystallized (functionalization). Wet-chemical application and laser post-treatment are performed several times to obtain thicker layers. The process development is supported by simulations of the laser-induced time-temperature sequences.

1 SEM image of the fractured edge of a laser-crystallized PZT layer.

2 Laser-crystallized PZT structures on a silicon substrate.

Results

Laser radiation can be used to crystallize single layers with thicknesses of about 50 nm as well as multiple layers with a total thickness of up to 200 nm. The columnar microstructure can be controlled by adjusting the laser process parameters. The laser-crystallized layers show almost the same ferro- and piezoelectric properties ($2P_r \approx 60\ \mu C/cm^2$, $d_{33} \approx 100$ pm/V) as those from the furnace process.

Applications

The applications of highly efficient piezoelectric layers range from sensor technology, for example, to measure structure-borne noise, and actuator technology in micropumps and relays, to inkjet printers all the way to use in communications technology.

The R&D project underlying this report is being carried out on behalf of the Federal Ministry of Education and Research BMBF under grant number 03VPP02223.

Contact

Samuel Fink M.Sc.
Telephone +49 241 8906-624
samuel.fink@ilt.fraunhofer.de

Dr. Christian Vedder
Telephone +49 241 8906-378
christian.vedder@ilt.fraunhofer.de

Fraunhofer Institute for Laser Technology ILT, www.ilt.fraunhofer.de
DQS certified by DIN EN ISO 9001, Reg.-No.: DE-69572-01