Fracture resistance of a doped PZT for multilayer actuators: Effect of mechanical load and temperature

R. Bermejo

Institut für Struktur- und Funktionskeramik, Montanuniversität Leoben, Peter Tunner-Straße 5, A-8700 Leoben

raul.bermejo@unileoben.ac.at

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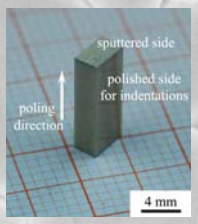
Motivation

The crack growth resistance of a doped PZT ceramic is evaluated after combined thermo-mechanical loading between room temperature (RT) and 400 °C. The thermal-, stress-induced depolarisation effects due to domain switching are assessed by the indentation fracture (IF) method.



Material of study

Commercial bulk soft doped-PZT specimens (4 x 3 x 10 mm^3) were polished, sputtered with Cr-Ag and poled in longitudinal direction with E = 2 MV/m.

Experimental procedure

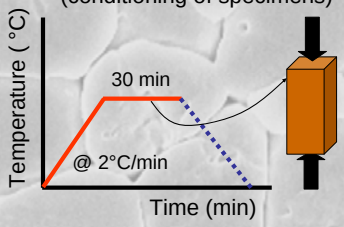
I. **Mechanical load in compression** is applied along the longitudinal axis **at a certain temperature**

II. After cooling down, **specimens** are **indented.** Parallel and normal **cracks** to E-field are **measured**

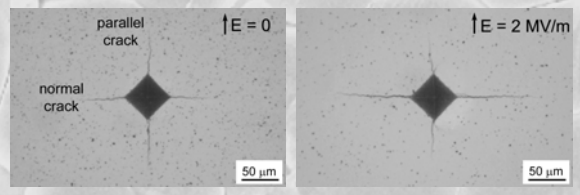
III. **The fracture resistance** in both directions is determined from the **length of the cracks**

Thermo-mechanical tests

(conditioning of specimens)



Indentation Fracture method



Fracture resistance model

$$K_F = \chi \frac{P}{a^{3/2}}$$

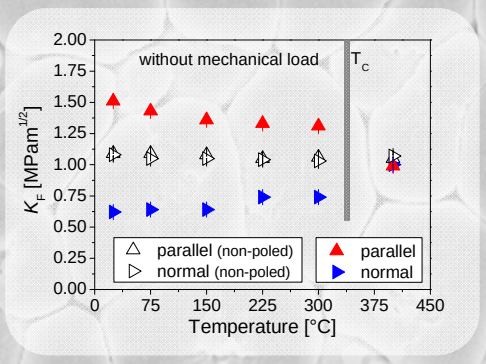
K_F = Fracture resistance

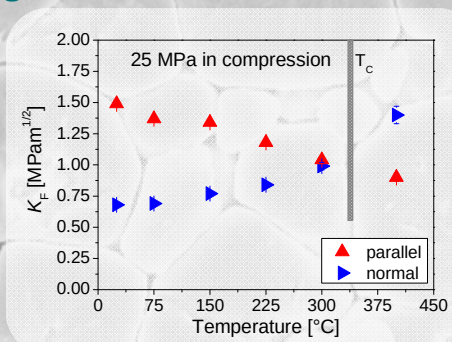
P = Indentation load

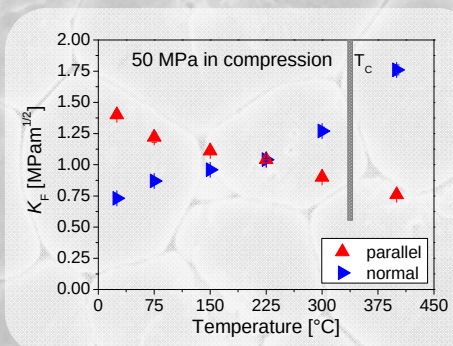
a = Crack length

χ = Crack shape factor calibrated on bulk-PTZ with the SEVNB method [1]

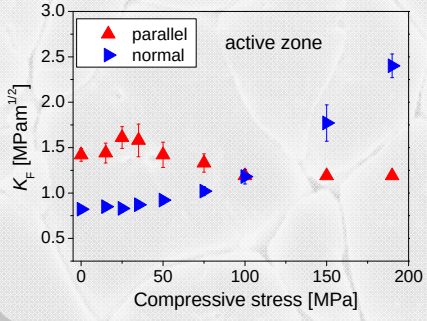
Crack growth resistance on bulk PZT

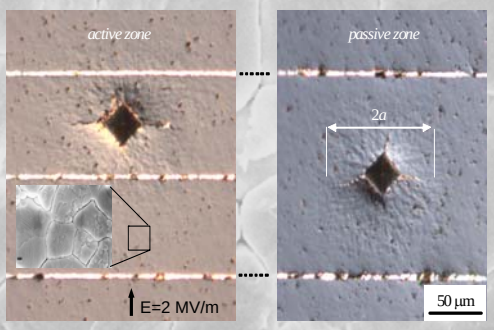


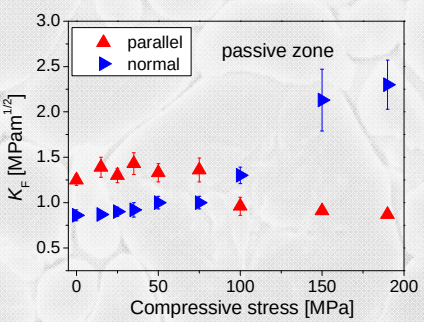




Application to Multilayer Piezoelectric Actuators







Conclusions

- Clear anisotropy (parallel and normal to the poling direction) in the resistance to crack propagation of PZTs
- Depolarisation effect of temperature is enhanced by mechanical compression load in poling direction
- Possible application of the IF method to qualitatively estimate the poling state of MPAs

References [1] R. Bermejo, H. Grünbichler, J. Kreith, C. Auer, "Fracture resistance of a doped PZT ceramic for multilayer piezoelectric actuators: Effect of mechanical load and temperature", *J. Eur. Ceram. Soc.* 30 (2010) 705-712

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