Temperature Dependent Electrical fatigue Studies on Bulk Piezoceramics

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Outline

- Introduction
- Motivation
- Experimental characterization
- Electrical fatigue results for different loading cases
- Deterioration of material properties
- Summary
Sensor

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Application: Structural health monitoring

$$D = d \cdot \sigma + \kappa \cdot E$$

$$\varepsilon = C : \sigma + d^T \cdot E$$

Sensor

Piezoelectric Material

Stress

Piezoelectric Effect

Courtesy: www.keramverband.de

Courtesy: www.aeronautics.sd.tmu.ac
Actuator

Deforms when voltage applied

Piezoelectric Material

Piezoelectric Actuator

Application: Ink jet printer

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\[ D = d \sigma + \kappa \cdot E \]

\[ \varepsilon = C : \sigma + d^T \cdot E \]
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Macro to Microstructure

Courtesy: Okayasu.M ceramic international
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Objective

- To evaluate the performance of poled Bulk Piezoceramics (PZT 5A1) are subjected to bipolar electric cyclic fatigue exposed to elevated temperature under conditions equivalent to those of stack actuator applications.
- To carry out parametric study in order to understand the deterioration caused by Thermo-Electric fatigue loading condition.
Experimental characterization

**STIMULUS**
- Electrical
- (Cyclic load)

**APPLY**
- Isothermal
- PZT

**RESPONSE**
- strain
- Charge

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Electrical cyclic loading

Case :1
- High Voltage
- Electric field higher than Ec
- Closer to saturation the greater the fatigue

Case :2
- Low Frequency
- More time for E to affect domains and difficult movement
- Domains become set = greater internal stresses to be overcome in reverse cycle

Case :3

The selection of waveform

Sine and triangular wave
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Case 3: Bipolar electrical fatigue

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Unrecoverable properties

Inference:

• The domain wall causes more deterioration during frequent domain switching.
• In unipolar and bipolar at lower fields will not cause domain switching, hence there is no deterioration
Deterioration of material properties

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Summary

- Electrical fatigue experiments are performed on Bulk Piezoceramics at different loading amplitude and environment.
- Material properties are identified in quasi static and at dynamic fields, the influencing parameter for deterioration identified as domain switching.
- Thus the present study explores the insight of Electrical fatigue effects on 1-3 piezocomposites. The results obtained will be useful the device design of the material.
References


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