Mechanics of ferroelectrics

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The mechanics of a ferroelectric material are about as complex as those of a metal with plasticity and phase transitions [1,2]. Two fundamental aspects are involved in a ferroelectric, a ferroelastic component, that means strongly nonlinear and hysteretic strain response of the material to mechanical stresses, and piezoelectric coupling which couples electrical to mechanical fields and vice versa.

In this tutorial I will briefly elaborate on the fundamental equations that govern linear couplings, namely elastic response and piezoelectricity and then describe the influence of ferroelectric and ferroelastic domains on the macroscopic material behavior. Taking this as a base, I will demonstrate the numerous fashions in which mechanics enter electrical, piezoelectric, and magnetoelectric properties of this material class. The perspective is mainly of an experimentalist where the multiple factors influencing experiment must be taken into account. These typically do not enter theoretical considerations. A discussion of the multifold influence of ferroelectric domains on material behavior will be covered. Very briefly, deterioration of materials due to mechanical factors will be shown including microcracking and macrocrack formation.

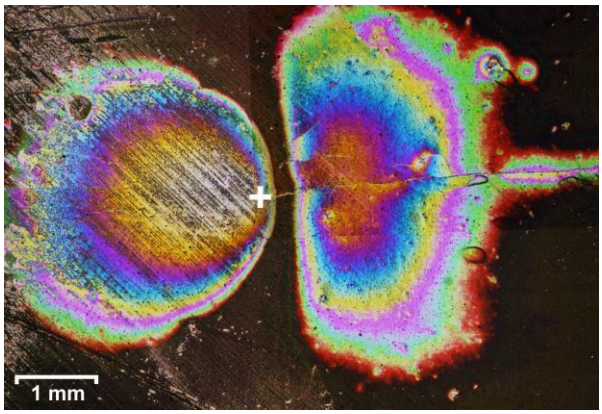

Figure 1. Image of the mechanical stress/strain state around a crack in a ferroelectric [3].

The tutorial will in the end summarize the different fields of applications for mechanical properties of ferroelectrics, namely piezoelectric actuators, ultrasonic devices and magnetoelectric composites.

References

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