# Dielectric and Piezoelectric Performance of Soft PZT Piezoceramics Under Simultaneous Alternating Electromechanical Loading

Dayu Zhou* and Marc Kamlah

Forschungszentrum Karlsruhe, Institut fuer Materialforschung II, D-76021 Karlsruhe, Germany

Modern piezoelectric transducers normally have complicated structures and work under severe loading conditions. To produce large actuation displacement, a high driving field must be applied. In addition, novel actuator applications require the active material to operate under significant compressive stress preloads to avoid tensile failure. For the purpose of design, working condition optimization, and especially reliability assessment of novel actuators, it is necessary to determine and understand the fundamental properties of piezoceramics under loading scenario simulating the in-service environment.

Our previous work proved an enhancement of the high-field dielectric and piezoelectric properties of piezoceramics exposed to a precise range of constant compressive prestress. In this study, high electric field induced polarization and strain responses were experimentally evaluated for a commercial soft PZT material subjected to cyclic mechanical load with different mean stresses and amplitudes. When the stress is applied in-phase with electrical loading, the polarization and strain outputs are found to monotonically decrease with an increase in stress amplitude, until mechanical loading completely impedes the piezoelectric response. An inverse effect occurs for the out-of-phase electromechanical loading tests, in which the polarization and strain outputs increase with increasing stress amplitude. In general, the enhanced polarization and strain responses are accompanied by an unfavorable increased hysteresis and nonlinearity. An attempt has been made to explain the experimental findings by simultaneously taking into account the effects of elastic deformation, domain reorientation, and piezoeffects.

* Corresponding author. Tel: +49-7247-82-5855; fax: +49-7247-82-2347.
E-mail address: dayu.zhou@imf.fzk.de (D. Zhou)