Advanced Mechanical Characterization for Piezoelectric Automotive Sensor Applications

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Piezoelectric ceramics with the solid solution of $PbZr_{1-x}Ti_xO_3$ (PZT) are state of the art materials for applications in the automotive business sector. By using them as actuators or sensors, PZT materials have enabled technological innovations in the fields of performance, safety and reduction of exhaust gas emission. For new sensor applications, the direct piezoelectric effect is used under small and large compressive and tensile mechanical loads. To ensure the electric sensor function as well as the mechanical reliability during product lifetime, detailed knowledge about the nonlinear ferroelastic material behavior of PZT as well as lead free piezoelectrics is indispensable.

In this presentation, an approach of analyzing and modelling the complex nonlinear mechanical and piezoelectric behavior is presented by using the example of a tetragonal PZT ceramic. Experimental results are used as input parameters for a finite element approach, which includes the nonlinear material behavior in a constitutive model. As a result, the electrical and mechanical sensor behavior are predicted under large signal conditions. The requirements for PZT ceramics in modern applications will be compared to the performance of lead-free piezoelectric materials.