Study on the self-sensing mechanism of piezoelectric actuators

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Abstract

Obtaining real-time force and displacement states of piezoelectric actuators is a necessary condition for accurate control. Self-sensing methods that utilize the piezoelectric actuator itself as the sensor have attracted much attention due to low cost and portability. However, researches on the self-sensing of piezoelectric actuators mostly focuses on phenomenological models, and reports on fundamental physics are infrequent. In this work, theoretical calculations and experimental measurements were combined to expose the physical mechanism of self-sensing. Taking the widely used barium titanate ($BaTiO_3$) piezoelectric materials as an example, the influence of intrinsic and extrinsic contributions on the capacitance under mechanical-electrical coupling were systematically studied. The data obtained from material and electrical characterizations were used to quantify the contributions of various parts in piezoelectric materials to capacitance, and the obtained theoretical formula is in good agreement with experimental measurements. This study will further promote the applications of self-sensing in piezoelectric actuators.

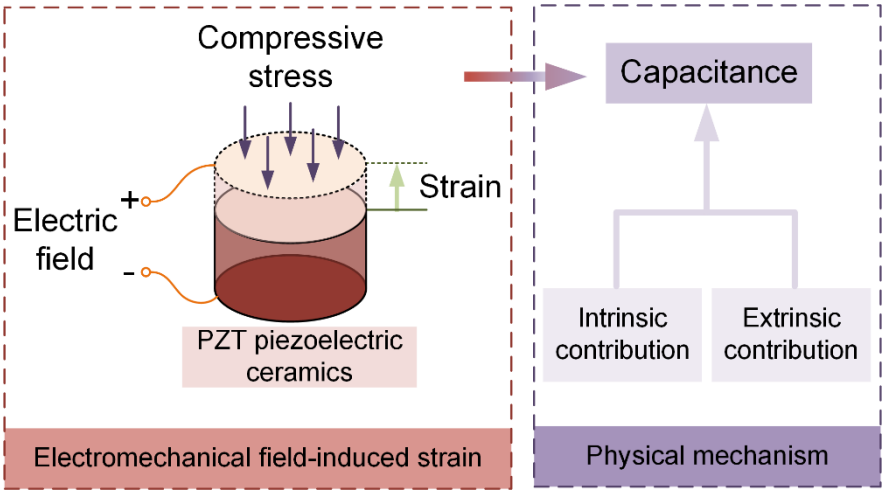

Figure 1. Describe the capacitance from intrinsic and extrinsic contributions of piezoelectric actuators under the mechanical-electrical coupling.

Keywords: Self-sensing; Piezoelectric actuator; Capacitance; Domain.