

Piezoelectric Fundamentals: Materials and Transducers

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This short course will include two parts: the first part will be focused on piezoelectric fundamentals and surveys of piezoelectric materials, given by Prof. Shujun Zhang, and the second part will be focused on ultrasonic transducers, given by Prof. Sandy Cochran. Practical demonstrations will be included.

Piezoelectric materials are at the heart of electromechanical devices used in applications such as medical imaging, high intensity focused ultrasound (HIFU), industrial nondestructive evaluation (NDE) and piezoelectric sensors, to name a few. In this short course, the advantages and disadvantages of piezoelectric materials are discussed based on the requirements (figure of merit) of various applications. The short course will start from the fundamentals of piezoelectric materials, including symmetry, stereographic projections, constitutive equations and the electromechanical coupling coefficients, structure origin of piezoelectric and ferroelectric materials to phase transition, morphotropic phase boundary and polymorphic phase transition in different ferroelectric materials. It will then go on to consider the development of piezoelectric materials, surveying this over the past 100 years, and their fabrication process and application range. Emphasis will be placed on recent developments of the high performance relaxor-PbTiO₃ (PT) ferroelectric materials and high temperature non-ferroelectric piezoelectric single crystals, considering general issues in piezoelectric applications. The second part of the course will focus on piezoelectric ultrasonic transducers and arrays, describing their basic structure and the constraints and degrees of freedom in their designs for different applications. Composite materials will be described and design techniques, including a selection of different simulation procedures will be outlined. A procedure to choose the piezoelectric material for any given application will be described and a short case study will illustrate how the choice can make a real difference in piezoelectric transducer performance. The behaviour of piezoelectric material and of transducers will be demonstrated with simple instrumentation.