

MATERIALS ENGINEERING SEMINAR

“ON THE TUNABILITY OF HIGHLY ANISOTROPIC COMPOSITE PIEZOELECTRIC FILMS: PROCESSING AND APPLICATIONS”

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Purdue MSE Ph.D. Final Exam

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ABSTRACT

Polymer films possess many advantageous properties, such as mechanical flexibility, toughness, impact resistance, optical transparency, light weight, and low cost, but their behavior related to temperature stability and thermal conductivity and lack of select functionalities render them unsuitable for key applications. In the context of smart materials, piezoelectric ceramics and single crystals provide unmatched electromechanical couplings, mechanical strength, and chemical inertness, at the expense of being brittle, opaque, and high cost. A synergistic combination of properties can be achieved by combining both materials in an anisotropically structured ceramic/polymer composite (with quasi-1–3 connectivity) by the application of external electric field (E-field). In a process called dielectrophoresis, the particles align into through-thickness columns comprising a nanocolumn forest. As a result, the complementary properties greatly enhance the resulting performance, promising to revolutionize the class of smart materials with high-performance applications in actuators, sensors, and transducers. These particle-filled composites also allow for great design flexibility regarding the type of functionalization and the connectivity of each phase. Following the materials-science paradigm comprising the sequence of processing, structure, and properties, the work on these piezoelectric composite materials is broadly organized into material selection, processing, and applications.

In the first study, the kinetics of particle-chain alignment are modeled as a linear step-growth polymerization and the rheokinetics are modeled with the dual Arrhenius chemoviscosity model. Employing the direct piezoelectric effect, a characterization of the vibration response of the composites complements an evaluation of their suitability as vibration sensor for motor fault detection. Second, for impact sensing, the efficacy of the piezoelectric composite films is evaluated with respect to a novel conceptual sensing system for automotive applications, such as vehicle-to-pedestrian collision detection. Third, applying the indirect piezoelectric effect for sound production as an electroacoustic loudspeaker, the piezoelectric composite films represent a novel approach to flat-panel loudspeakers that are tunable in modulus, with opportunities for mechanical flexibility, optical transparency, and large-area coverage.

Date: Tuesday, May 9, 2023

Time: 9:00 A.M.

Place: BIRCK 1001 or via Webex: <https://purdue.webex.com/join/cakmak>



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