Flexible Piezoelectric Nano-sensor For Infrastructure Sensing

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Abstract

Piezoelectric sensors have been widely used in the field of infrastructure sensing. However, the materials used for piezoelectric sensor fabrication are dominated by ceramic materials, which has the shortcoming of intrinsic brittleness. Therefore, the application of the piezoelectric sensors is limited to the condition with tiny strain levels. This study set out to develop a piezoelectric nano-sensor with good piezoelectricity and flexibility to address the current bottleneck of piezoelectric-based infrastructure sensing.

The experiment program starts from the polymer-based piezoelectric materials, PVDF (Polyvinylidene fluoride or polyvinylidene difluoride) nanofiber, synthesis by using electrospinning process. The materials characterization results reveal the correlation within the materials synthesis methods, nanostructure, and material properties. The materials synthesis techniques for nanostructure control and improve piezoelectric performance are presented in this dissertation. The piezoelectric nano-sensor was fabricated by using an ink-jet printing process. This study further utilized the COMSOL Multiphysics simulation to guide the piezoelectric nano-sensor packaging design from the perspective of energy dissipation. The optimized piezoelectric nano-sensor was then used for civil engineering materials strength sensing and damage detection. The electric response from the piezoelectric nano-sensor is sensitive to the mechanical strength of the sensing structure. The piezoelectric nano-sensor's voltage output can also be a good indicator for damage detection at a decent strain level. A natural progression of this work is to explore the roll-to-roll manufacturing methods for large-scale piezoelectric nano-sensor fabrication. As part of the infrastructure component, the piezoelectric nano-sensor is effective for the mechanical property evaluation and preliminary damage assessment. Moreover, incorporating the artificial intelligence-guided signal process, the piezoelectric nano-sensor could better understand the condition of the infrastructure.