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Multicomponent Imaging in Helical Fiber Designs for Low Frequency Acoustic Sensing

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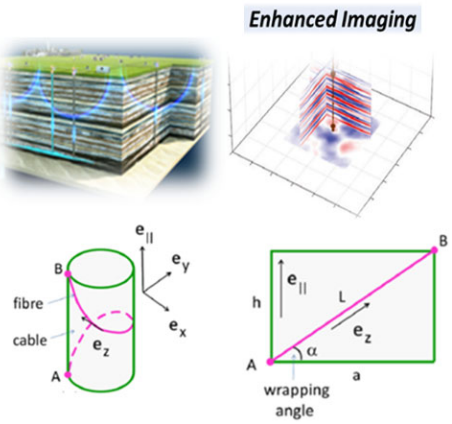
Abstract

Distributed acoustic sensing (DAS) is a fiber optic sensing (FOS) technique that derives external parameters such as strain or temperature from optical distortions in backscattered light. Typical FOS systems consist of a light source, optical fiber, sensing elements, detectors, and a signal processing algorithm. While there exists a number of commercially available DAS systems that have varying degrees of sensitivity, dynamic range, spatial resolution, linearity, etc., all these systems are primarily sensitive to axial strain (ϵ_z). Reconstruction of the entire strain tensor, denoted multicomponent imaging, has immediate use in a variety of applications such as micro seismic sensing and reservoir mapping. Until recently, multicomponent imaging has failed practical implementation across the described applications due to cost, resolution, sensing lengths, and no real-time delineation of the S and P waves. Additionally, no recent advances in DAS have been able to solve the issue of low frequency sensing while maintaining high resolution. The work proposed here will introduce a sensor design built for multicomponent imaging with real-time reconstruction of the strain tensor, while demonstrating sub 10kHz sensitivity. Numerical modeling with COMSOL v5.3a will be used as the framework for this proposal further validating the hypothesized multi-helical fiber bulk polymer cladded bundle design. Experimental fabrication methods will be introduced in addition to a brief mathematical overview into low frequency DAS sensing and multicomponent imaging.



Biography

Zachary Hileman is a 3rd year PhD candidate in the Materials Science and Engineering Program, expecting to defend December 2021. He received his BS degree in Biomedical Engineering from Rensselaer Polytechnic Institute in 2017. During his undergraduate Zachary co-founded an engineering company initially funded through NSF I-Corps while working in an Intel sponsored lab, as an undergraduate research assistant. For his PhD degree Zachary contributes to multiple Department of Energy Grants utilizing both numerical modeling and experimental design, as lead graduate researcher. His primary research interests are optics, acoustics, sensors, and magnetic materials. Zachary's thesis will introduce new multiparameter magnetic sensing designs for various commercial and industrial uses.