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DEVELOPMENT OF A LOCALIZED RESONANCE MEASUREMENT SYSTEM USING LASER-BASED ULTRASOUND GENERATION

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ABSTRACT

In this work, a laser ultrasound system is being developed for localized resonance measurements in heterogeneous materials. Specifically, the system is designed to excite ultrasound energy in microscale samples fabricated in materials that are spatially heterogeneous, thus exciting resonance modes locally in different areas of the sample. The samples can be made by additive manufacturing, as in the case of low density materials and acoustic metamaterials, or using traditional removal techniques such as EDM/FIB machining. The system has been benchmarked against previously analyzed samples made from different Ti and Ni alloys and found to produce resonances similar to those measured using traditional RUS. The system was also used to map the mode shapes of these samples for rapid and robust RUS of large scale samples. The system was then applied to detection of resonance modes in microscale samples analyzed in a previous immersion ultrasound experiment. The system design and benchmarking results will be given in this presentation.

Keywords: resonance, laser excitation, laser ultrasound

NOMENCLATURE

RUS	resonant ultrasound spectroscopy
LRUS	laser-based RUS

1. INTRODUCTION

RUS has been applied to measuring the elastic properties of many different types of materials and geometries [1]. However, one of the more challenging aspects of RUS has been the requirement for canonical geometries and boundary conditions, as well as samples on the mm size scale. The geometry and boundary condition assumptions are necessary when numerically efficient models relying on global discretization techniques, such as the Rayleigh-Ritz method, are used in the inverse problem. These assumptions are alleviated by going to local discretization techniques such as FEM. However, the size of the sample is typically limited by the excitation-detection mechanisms used in the experiment. To excite and detect resonance modes in microscale samples, authors have mostly relied on laser excitation and detection using the established technologies developed for laser ultrasound measurements [2, 3]. However, the samples in these studies have been mostly canonical geometries and boundary conditions.

In this work, an LRUS system is being developed to characterize the resonances of spatially heterogeneous materials. By machining microscale samples from materials, the sample resonances are related to the local elastic properties in the materials from which they are made. A previous effort has analyzed such samples using immersion ultrasound excitation and laser detection [4]. However, it was found that local, non-contact excitation would be more successful in isolating the resonances of the sample under test. This presentation will show the system design, the results from benchmarking experiments, and the application to localized measurement of resonances in microscale samples.

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