Abstract: "Surface Acoustic Wave Characterization and Interdigitated Transducer Optimization for Stress-Directed Phenomena"

Surface acoustic wave (SAW) devices offer a new platform to study stress-directed phenomena in semiconductor systems and address a recognized need for new quantum device fabrication techniques. In this work, a high-frequency interdigitated transducer (IDT) assembly forms a SAW-cavity resonator on semi-insulating GaAs(100). The IDT devices are characterized using a variety of techniques, including vector network analysis and atomic force microscopy. Furthermore, a 2-D Raman imaging technique has been developed to directly measure the stress fields produced by the standing SAW. Atomic force microscopy and 2-D Raman microscopy indicate localized stress field amplitudes on the order of 10^8 Pa for current device designs. Finite element method (FEM) modeling using COMSOL Multiphysics provides the electrical and mechanical response characterization needed to predict unexpected device behaviors, unattainable using typical phenomenological modeling methods. A computational parametric analysis studies the effects of device geometry on key device performance factors such as the device resonance frequency, effective coupling coefficient, quality factor, and maximum acoustic surface displacement. High-temperature characterization of these devices is completed up to 177 °C for initial high-temperature device performance testing and demonstrates stress fields comparable to the room-temperature measurements. Future experiments will explore the formation of 3-D quantum structures under a patterned stress field at high temperatures, utilizing strain-induced asymmetric bulk diffusion.

Biographical Information:

Brian Rummel earned his B.S. in Chemical Engineering from Drexel University (2015) and his M.S. (2018) and Ph.D. (2022) in Nanoscience and Microsystems Engineering from the University of New Mexico. Brian's graduate research focused on high-frequency interdigitated transducer devices and their application in studying stress-directed phenomena in semiconductor systems. This work revealed the significant, quantifiable, and controllable stress amplitudes obtained by standing acoustic waves through various characterization methods, including a novel acoustic imaging technique utilizing 2-D Raman microscopy and high-fidelity FEM modeling. Brian is currently a postdoctoral appointee at Sandia National Laboratories in Albuquerque, New Mexico, where he studies ultrawide bandgap semiconductor materials and their relevance in high-frequency and high-power electronics.