Abstract:
Nano-optomechanical systems (NOMS) with high-Q phonon modes have enabled the exploration of fundamental light-matter interactions at the nano-scale and the development of new classes of information processing devices that leverage the interaction of cavity coupled phononic and photonic modes. Guided-wave optical devices, where non-resonant optical modes interact with resonant phonon modes, are promising for broadband (i.e. beyond 20GHz) chip-scale radio-frequency (RF) filtering, phononic time-delay lines, low-noise stimulated Brillouin scattering (SBS) oscillators, and other applications benefiting from enhanced opto-mechanical forces.

It will be shown that sub-wavelength field confinement in nano-photonic waveguides produces a new regime of SBS, where radiation pressure plays a critical role in mediating photon-phonon interactions. At such length scales, the strong interaction of light with the boundaries of a nano-scale waveguide radically enhances SBS for suitably chosen geometries through optical forces due to both electrostriction and radiation pressure. Measurements of fabricated devices using a coherent continuous-wave (CW) laser setup indicate SBS gain values as large as 1000 1/m/W in a 7mm-long device, equivalent to the SBS nonlinearity of more than a meter of conventional silica fiber.

However, frequency-domain (i.e. CW) excitation and characterization of guided-wave NOMS devices is limited by other processes occurring along with the optical forces, such as free-carrier generation and the Kerr effect, which appear as background noise and set fundamental limits on the detection sensitivity. Time-domain spectroscopy using ultrafast optical pulses can provide high sampling resolution of transients over long durations, thus allowing for separation of various physical processes on different time scales. By isolating long-lived phonon transients from the instantaneous Kerr effect and free carrier effects, the phononic impulse response of NOMS devices has been measured with greater than 40dB of resolution.

Finally, a new RF photonic filter based on photon-phonon interactions in our NOMS devices will be presented. This filter consists of two distinct optical waveguides surrounded by three sections of phononic crystal (PhC) patterning. The PhC structures were engineered to have a phononic bandgap from 2.6 GHz to 4.5 GHz, creating two defect modes that combine to form a high-Q phononic cavity. The measured second-order RF filter responses demonstrate an unrivaled combination of high power handling and wavelength (and frequency) insensitivity. The controllable photon-phonon interactions offered by this system represent a novel technology for agile, chip-scale RF optical signal processing.

Biography:
Charles Reinke is a Senior Member of Technical Staff in the Applied Photonic Microsystems department at Sandia National Laboratories. He performs basic research involving theoretical studies of novel nano-photonic and phononic devices, with applications in solar power generation, integrated cooling of microelectronics, and RF photonics. Charles received his B.S. in Physics from Jackson State University and B.S. and M.S. and Ph.D. degrees in electrical engineering from the Georgia Institute of Technology. His graduate work studied efficient numerical techniques for the simulation of nonlinear optical effects in photonic crystal devices, and the measurement of propagation loss photonic crystal waveguides.