Nanoscale Si_3N_4 Tuning Fork Cavity Optomechanical Transducers

Speaker: Rui Zhang, Yundong Ren, Vladimir Aksyuk, Kartik Srinivasan, Yuxiang (Shawn) Liu – Worcester Polytechnic Institute, Worcester, MA

E-Mail: Rzhang@wpi.edu

Abstract

Cavity optomechanics, which is enabled by recent development of nanofabrication technology, involves coupling between nanoscale mechanical resonators and optical cavities via radiation pressure. The optomechanical coupling enables near-field optical readout of mechanical motions with a resolution as high as sub-fm (10^{-16} m). Combined with the advantages of being batch fabricated and no alignment required, cavity optomechanical sensors provide a compact, integrated sensing platform for many applications ranging from accelerometers and gyrometers, to biological sensing.

In this work, we design, fabricate, and characterize the temperature-dependent optical and mechanical performances of a silicon nitride, nanoscale tuning fork cavity optomechanical transducer. The mechanical resonances of the tuning fork transducers can be engineered by designing the geometry of the clamp, which helps to enhance the sensitivity by achieving both high mechanical resonance frequencies (f_m) and high mechanical quality factors (Q_m). We further investigate the influence of temperature on the tuning fork. Experiment results show that f_m increased linearly with an increase of temperature. Confirmed by simulations, f_m changes were caused by 1) temperature induced Young's modules change and 2) the thermal expansion coefficient mismatch between Si and Si_3N_4. This fundamental understanding will help to design both temperature independent mechanical resonators and thermometers with high sensitivity. This work may find application when both high temporal and force resolution are important, such as those in compact sensors for atomic force microscopy.