Sub-wavelength soft-clamping: monolithic quantum optomechanical transducers at room temperature

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Time: **10:00-11:00 am, 8/26, Friday**
Room: **BRK_1001**

Abstract: Thermal motion of a room-temperature mechanical resonator typically dominates the quantum backaction of its position measurement. This is a longstanding barrier for exploring cavity optomechanics at room temperature. A "quantum-enabled" optomechanical system consists of an optical cavity and a mechanical resonator with ultra-low quantum decoherence, which are strongly coupled to each other via the optomechanical interaction. High stress silicon nitride has enabled nanomechanical resonators with exceptionally low dissipation at room temperature [1]. Monolithic integration of high-Q resonators with optical cavities has been limited due to the complexity of the device fabrication and long device sizes required for conventional high Q resonators. In addition, the previous demonstrations of such systems showed limited optomechanical couplings thus a limited single photon cooperativity.
In this seminar, I present the design, fabrication and characterization of three different classes of nanomechanical resonators clamp-tapered [2], fractal-like [3], and polygon resonators [4], which support perimeter modes, with Q factors exceeding 3 billion at room temperature and their optical readout using an integrated nearfield nano-optomechanical transducer using high stress silicon nitride [4]. Our transducer features a one-dimensional Fabry-Perot optical cavity integrated with a high-Q nanomechanical resonator. Our best performing devices show on-chip optomechanical transducers with single photon cooperativities as high as 123 with mechanical quality factor of 120 million at room temperature. The developed system is of great interest to the optomechanics and sensing community. I will also talk about NanoFab that is an open science platform for nanofabrication (nanofab-net.org) [5].

Bio: Mohammad Bereyhi obtained his Electrical Engineering and Physics double bachelor of science in 2016 from Sharif University of Technology in Iran. He joined Swiss Federal Institute of Technology Lausanne (EPFL) in 2016 after an internship in Max-Planck Institute for the Science of Light in Erlangen, Germany. He obtained his PhD in Electrical Engineering under the supervision of Prof. Tobias Kippenberg in the Laboratory of Photonics and Quantum Measurements (LPQM) on "Ultra low decoherence nano-optomechanical systems". Mohammad worked on ultra high Q factor nanomechanical resonators and their integration with optical cavities for cavity quantum optomechanics and sensing.
He was the recipient of a Marie-Curie EU PhD fellowship during his PhD and the prestigious Open Science Grant of EPFL from 2019 until 2022. He founded Nanofab-net - an online open access nanofabrication knowledge sharing platform (nanofab-net.org) - in the framework of EPFL's Open Science Initiative.

References:
[1] Ghadimi, A. H., Fedorov, S. A., Engelsen, N. J., Bereyhi, et al. "Elastic strain engineering for ultralow mechanical dissipation". Science (2018).
[2] Bereyhi, M. J. et al. "Clamp-tapering increases the quality factor of stressed nanobeams". Nano letters (2019).
[3] Bereyhi, M. J. et al. "Hierarchical tensile structures with ultralow mechanical dissipation". Nature Communications (2022)
[4] Bereyhi, M. J. et al. "Perimeter Modes of Nanomechanical Resonators Exhibit Quality Factors Exceeding 10^9 at Room Temperature". Physical Review X (2022)
[5] Bereyhi, M. J., & Kippenberg, T. J. "Nanofabrication meets open science". Nature Nanotechnology (2021)