Squashing the motion of a crystalline piezoelectric nanomechanical resonators

**Background:** High-mechanical quality factor ($Q_m$) nanomechanical resonators are crucial for applications where low noise and long coherence time are required [1]. We have demonstrated $Q_m$ above $10^7$ in strained crystalline AlN nanomechanical resonators grown directly on Si substrate (Fig 1 a,b) [2], reaching a $Q_m \times f_m$-product close to $10^{13}$ Hz, sufficient to support a single quantum coherent oscillation at room temperature. AlN is a piezoelectric material, that has been used for interfacing GHz nanomechanics with superconducting qubits [3] or direct piezoelectric read-out of AlN-based nanomechanical resonators for sensing applications [4]. In general AlN can facilitate coupling of optical, mechanical and electronic degrees of freedom in the same material system [5]. This Master thesis project is a step in this direction.

**Goal of this project:** The first step of the project is to fabricate and characterize the mechanical properties of the resonators made from an AlN heterostructure. The novelty of this step is the utilization of epitaxial growth to integrate conductive layers around the AlN layer. This is contrary to conventional sputtering of metal contacts onto AlN that may degrade $Q_m$. The second step is to form contacts with the conductive layers. Then you will measure the shift of mechanical frequency, $f_m$, via piezoelectric tuning. You will also apply parametric modulation of the mechanical resonance frequency $f_m$ which is a way to generate squashed or even squeezed states of mechanical motion [6], enabling improved sensing performance.

**What will you learn/get?**
- Physics of micro-mechanical resonators and their interaction with light.
- Interferometric optoelectromechanical experiments, vacuum experiment techniques.
- Fabrication and simulation of optoelectromechanical devices.
- Team work

**References**

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