Cavity Optomechanics with an Epitaxially Grown Microcavity

Background Cavity optomechanics studies the parametric interaction between an optical mode and a mechanical resonator mode. The motion of the mechanical mode can modulate both the length of the optical resonator, and therefore the frequency of the optical modes, but also the losses in the optical mode, see Fig. 1 (a) [1]. There are different applications for cavity optomechanical systems, e.g. sensitive optical detection of small forces, displacements, masses and acceleration, and manipulation and detection of mechanical motion in the quantum regime [1,2].
In our lab we work with a microcavity, that has a length on the order of the optical wavelength $L_g \sim \lambda$. It consists of a suspended InGaP membrane, which is patterned with a photonic crystal (PhC), and a distributed Bragg reflector (DBR), see Fig. 1 (a). We were already able to observe optomechanical effects, e.g. the optomechanical spring effect in Fig. 1 (b) [3]. The addition of the PhC changes the optomechanical response and gives rise to new physics, such as bound states in the continuum (BIC).

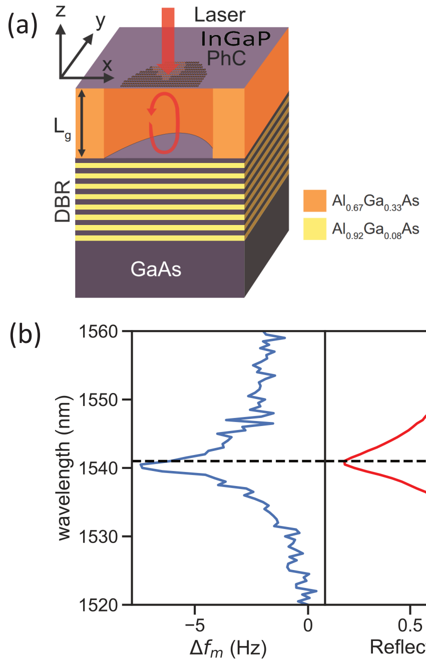

Figure 1: (a) Scheme of the optomechanical microcavity that consists of a thin InGaP membrane on top of a crystalline DBR. (b) Optomechanical frequency shift and reflectance dip of the optical cavity mode.

Project We can offer two different projects.
First of all, we would like to reduce the optical loss in the microcavity. This might be possible with the BICs, which are a result of an interference effect between the cavity mode and a guided resonance in the PhC [4]. For the right set of parameters, the optical losses in the microcavity should decrease by orders of magnitude [4].
Secondly, we would like to take first steps to implement feedback cooling to cool the mechanical mode to the quantum ground-state. This will be done with a high-Q_m mechanical resonator in a 4 K cryostat. The underlying assumption is that the amplitude and frequency noise of the laser and frequency noise of the cavity itself do not limit the achievable phonon occupation in the mechanical mode. The study and mitigation of these noise contributions will be the first task in such a project [2,5].

What will you learn/get?
- In-depth understanding of the optical and mechanical prroperties in the microcavity system.
- Understanding of noise in quantum sensing experiments and mitigation strategies.
- Team work in a stimulating research environment.

References
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