The proposed project explores hybrid nanomechanical systems based on silicon carbide (SiC). In particular, we will focus on the coupling of atomic-scale defects to the nanomechanical degree of freedom. These defects bear resemblance to the well-known NV-centers in diamond. However, the variety of possible defects is much higher as a result of the large number of polytypes of SiC. Our proposal specifically targets spin 3/2 defect. Unlike the well-known spin 1 defects in diamond, the spin 3/2 defects can be optically detected without additional application of microwave fields.

In the course of the project, we investigate nanomechanical resonators processed from two different SiC polytypes: On the one hand side, we will investigate hexagonal 4H-SiC grown on differently doped SiC substrates. 4H-SiC excels in its extremely high crystal quality, which results in a large spin coherence of the defect centers. However, the fabrication of resonators is involved, and moderate mechanical quality factors in the range of 1,000-10,000 are to be expected. On the other hand side, we will employ cubic 3C-SiC. This material is grown on (111) silicon wafers under strong tensile stress. This impairs the spin coherence, but enables large mechanical quality factors of several 100,000 as a result of the large tensile stress.

We will characterize the vibrational properties of nanomechanical resonators fabricated from both, complementary polytypes. Particular emphasis will be on the dominating dissipation mechanisms (as well as the prevailing tensile stress, for the case of 3C-SiC). Even more, the defect centers will be generated by focused ion beam irradiation in controllable manner and their spin coherence will be explored. The goal of the project is the realization of a hybrid nanomechanical system, in which the spin state can be manipulated or read out mechanically. This will be established experimentally via optically detected spin-mechanical resonance.

All in all, we propose to establish silicon carbide as an alternative material for hybrid spin-nanomechanical systems, which is easier to process than the prevalent single-crystal diamond. In addition, we will shed light on the potential advantages which arise from this new choice of material. The comparison between 4H-SiC and 3C-SiC will further show how the tradeoff between long spin coherence and high mechanical quality factor can be advantageously leveraged for hybrid nanomechanical systems.