High quality factor mechanical resonators based on WSe_2 monolayers

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Suspended monolayer transition metal-dichalcogenides (TMD) are membranes that combine ultra-low mass and exceptional optical properties, making them intriguing materials for opto-mechanical applications. However, the low measured quality factor of TMD resonators has been a roadblock so far. Here, we report an ultrasensitive optical readout of monolayer TMD resonators (Fig. 1) that allows us to reveal their mechanical properties at cryogenic temperatures. We find that the quality factor of monolayer WSe_2 resonators greatly increases below room temperature, reaching values as high as $1.6\cdot10^4$ at liquid nitrogen temperature and $4.7\cdot10^4$ at liquid helium temperature (Fig. 2). This surpasses the quality factor of monolayer graphene resonators with similar surface areas. Upon cooling the resonator, the resonant frequency increases significantly due to the thermal contraction of the WSe_2 lattice. These measurements allow us to experimentally study the thermal expansion coefficient of WSe_2 monolayers for the first time. High Q-factors are also found in resonators based on MoS_2 and $MoSe_2$ monolayers. The high quality-factor found in this work opens new possibilities for coupling mechanical vibrational states to two-dimensional excitons, valley pseudospins, and single quantum emitters, and for quantum opto-mechanical experiments based on the Casimir interaction.

References

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Figures

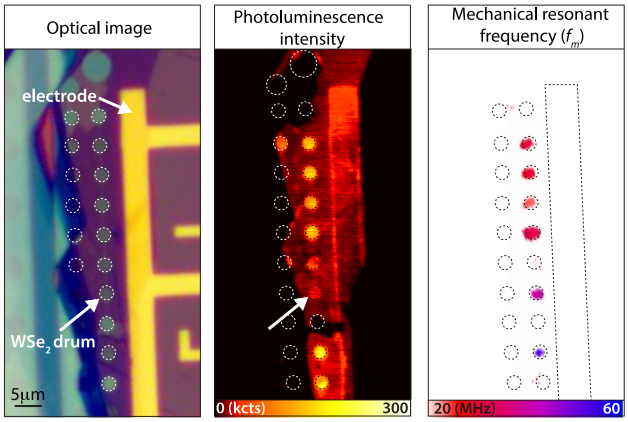

Figure 1: Optical Image, PL map and mechanical frequency of TMD resonators.

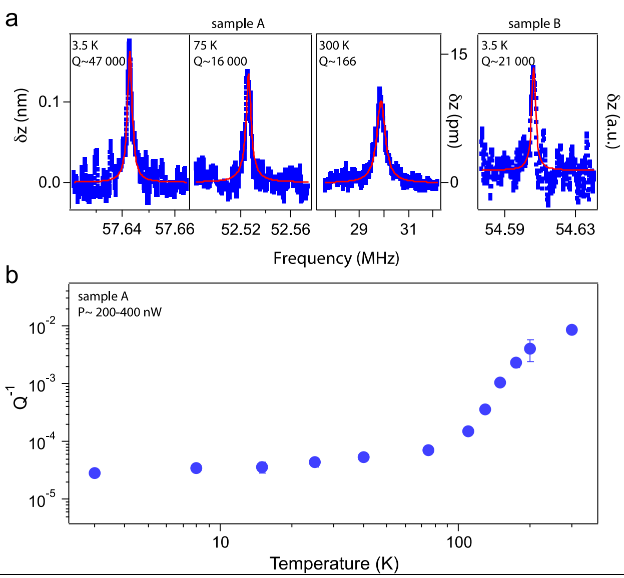

Figure 2: (a) Mechanical spectrums and (b) Mechanical dissipation versus temperature.