High quality factors in graphene and ultra thin Silicon nitride nanomechanical drums

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We have fabricated large ultrathin circular drum resonators from ultrathin silicon nitride (~15 nm, upto 1 mm in diameter) and monolayer graphene (upto 100 μm in diameter) and measured the resonant frequency, quality factor (Q) of different modes of these high tensile stress (> 1GPa) silicon nitride and self tensioned graphene drums using optical interferometric detection technique (Figure 1) . Silicon nitride drums are fabricated using electron beam lithography, with circularly symmetric etch release holes defined in nitride resulting in well defined boundaries which reduced the modal splitting observed at higher harmonics. Graphene resonators are fabricated by a combination etching the front and back faces of silicon using deep reactive ion etch resulting in circular through holes which marked the boundaries of the resonator. The measured mechanical dissipation (Q^{-1}) shows modal dependence for thick silicon nitride drums[1], indicating the influence of clamping losses in these tensioned membranes. However thinner (~15 nm) silicon nitride membranes and graphene drums[2] show a quality factor which is strongly size dependent (Figure 2) rather than mode dependent. We have measured extremely high quality factors (upto 4,000,000 for ultrathin silicon nitride membranes and up to 5,000 for graphene) at room temperature (Figure 2). These findings pave the way for identifying optimum size and modes of resonators for achieving low mass, high Q oscillators for optomechanical experiments with membrane in the middle geometry.

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1) *Modal dependence of dissipation in Silicon Nitride membrane resonators, V. P. Adiga*, et al Appl. Phys. Lett. **99**, 253103, (2011)
2) *High, Size-Dependent Quality Factor in an Array of Graphene Mechanical Resonators, Barton R A et al, Nanoletter, 11, 1232, (2011)*
3) *Electromechanical Resonators from Graphene Sheets, S. Bunch et al Science, 315, 490 (2007)*

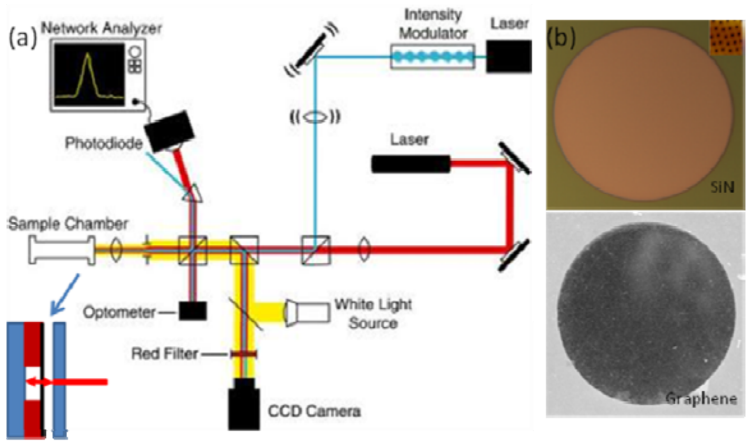

Figure 1(a): Optical interferometric set up involving a febry perot cavity[3]. (b)Optical and SEM images of ultrathin silicon nitride (300 μm) and graphene (70 μm) graphene drum respectively.

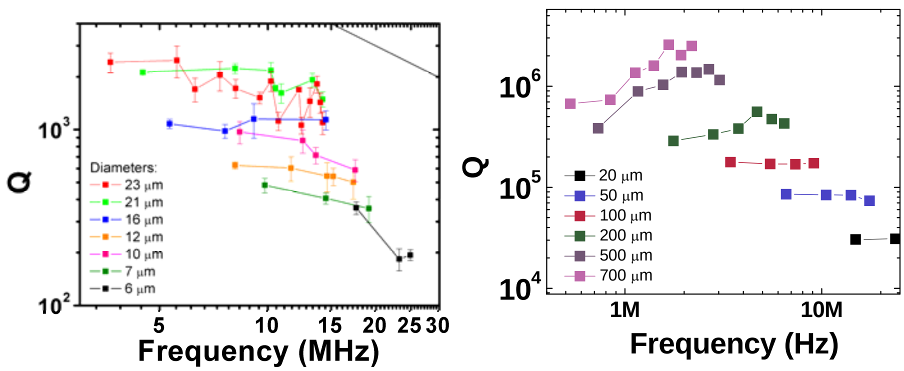

Figure 2 (a): Dissipation in graphene[2] and ultrathin (15 nm) SiN drum resonators as a function of diameter and modes showing a much reduced modal dependence compared to thicker SiN drums (not shown here)