The evidence of dissipation dilution effect in low stress graphene nano-electromechanical resonators

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Abstract
The low quality factor at room temperature is the key bottleneck for graphene nano-electromechanical resonator towards engineering applications[1]. The dissipation dilution theory has been demonstrated in highly stressed silicon-based resonators with high quality factor[2], which is also expected to be applicable to graphene[3]. In this work, we fabricated graphene resonators with outer phononic crystal shield by using the focus ion beam (FIB) etch process. The exfoliated Tri-layer graphene is characterized by Raman. The Resonance characteristics are carried out on a custom-built optical interferometry system at room temperature in vacuum. The devices exhibit reasonable low pre-stress in a range of 10MPa-40MPa [figure 2(b)].and reach Q value up to 769 even without clamp [figure 2(a)]. Meanwhile, the ratio of Q values of the first two vibration modes is close to 1 rather than 2.5, which indicates the unnegligible bending stiffness. According to the dissipation dilution model, the intrinsic mechanical quality factors [figure 2(c)] are extract by multiplied by the dissipation dilution factor extracted from the finite element models. The consistent values with small fluctuation in the range of 5 to 10 maybe more reasonable for graphene with higher surface dissipation compared to 69 for SiN_x[4]. Our results may provide new evidences to extend the dissipation dilution effect into low stress graphene resonator.

References

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[3] Descombin, Ayari, A.; Perisanu, S. el. al. Nano Letters 2019, 19 (3), 1534-1538.
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Figures

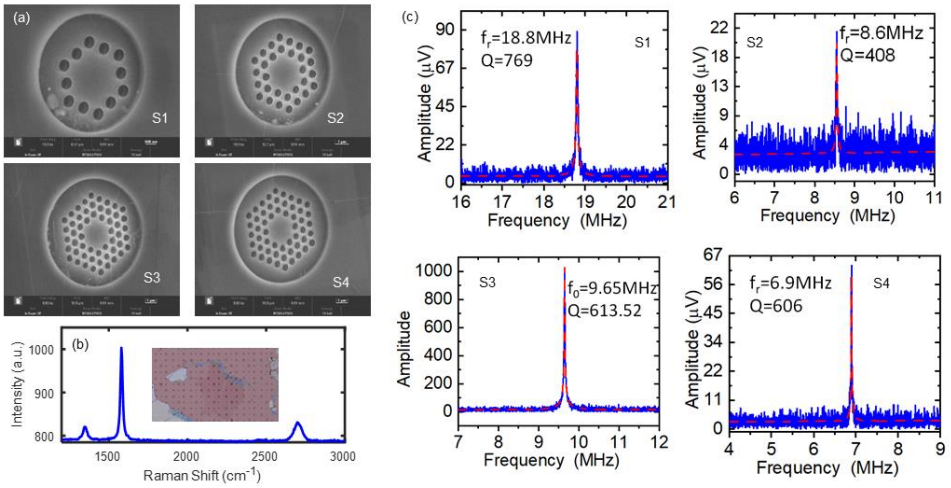

Figure 1: (a) SEM images. (b) Raman spectrum. (c) Resonances signals

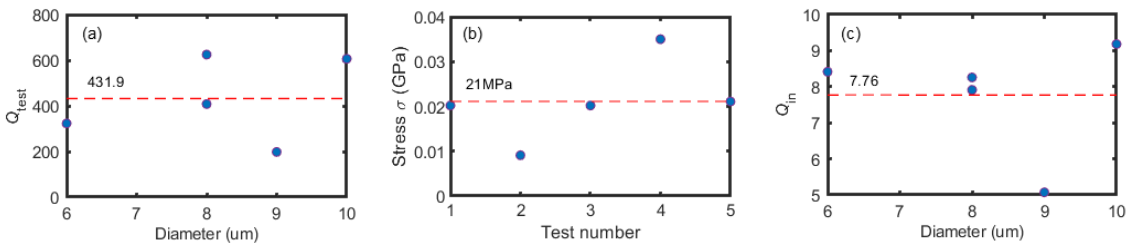

Figure 2: (a) Extracted quality factors. (b) Pre-stresses. (c) Extracted intrinsic quality factors.