Fabricating Arrays of Graphene Mechanical Resonators with High, Size-Dependent Quality Factors

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Graphene's unparalleled strength, stiffness, and low mass per unit area make it an ideal material for nanoelectromechanical systems (NEMS), but graphene resonators have been challenging to fabricate in large numbers and have exhibited poor quality factor.[1,2] Here, we present new methods[3] of fabricating large arrays of graphene resonators from CVD-grown graphene and discuss their properties.

We focus on circular graphene resonators with diameter of up to 30 microns (see Figure 1), for which we observe highly reproducible resonance frequencies and mode shapes, as well as a striking improvement in the membrane quality factor with increasing size.[4] The largest graphene resonators display quality factors as high as 2400 ± 300, about an order of magnitude greater than previously observed quality factors for monolayer graphene. Measurements of quality factor as a function of modal frequency reveal little dependence of quality factor on frequency and suggest that the quality factor is determined predominantly by the size of the membranes. These measurements shed light on the mechanisms behind dissipation in monolayer graphene resonators and demonstrate that the quality factor of graphene resonators relative to their thickness is among the highest of any mechanical resonator demonstrated to date. We conclude by reviewing methods of making large arrays of graphene resonators and provide an outlook for graphene NEMS and their applications.

1. J. S. Bunch *et al.*, Science **315**, 490 (2007).
2. C. Y. Chen *et al.*, Nature Nanotechnology **4**, 861 (2009).
3. A. M. van der Zande *et al.*, Nano Letters **10**, 4869 (2010).
4. Barton, R.A. *et al.*, Submitted.

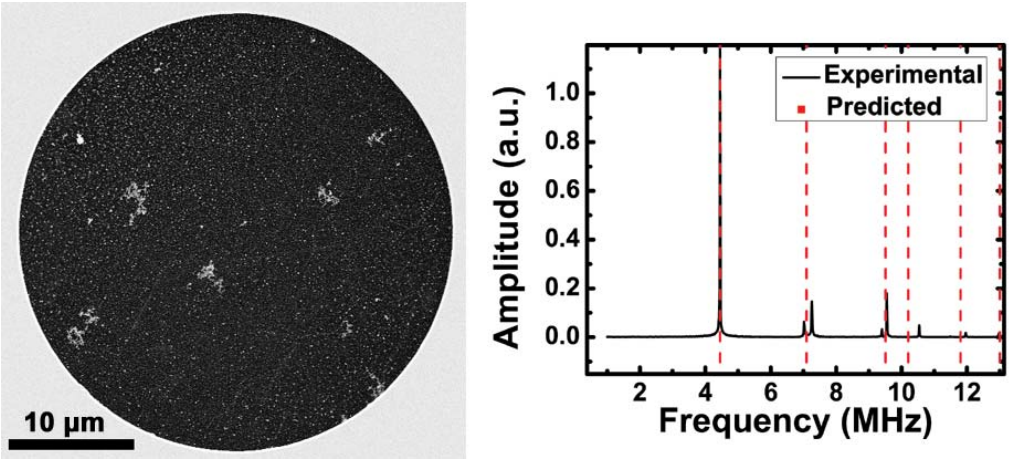

Figure 1: A SEM image of a circular graphene resonator and the resonance spectrum of one such resonator displaying high quality factor peaks. The predicted frequencies of all modes given the fundamental mode are shown with dotted red lines. Adopted from [4].