Fabricating Graphene-Silicon Nitride Heterostructures for High-Q Tunable Nanomechanical Resonators

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Nano-Electro-Mechanical Systems (NEMS) have applications in electrical signal processing and chemical sensing. For most applications, a nanomechanical resonator should have a high quality factor, integrated electrical readout of motion, and an electrostatically tunable resonant frequency[1]. The two most promising NEMS materials are high stress silicon nitride and graphene. Recently, it has shown that the doubly clamped high stress silicon nitride nano-string can exhibit Q's on the order of a million even at room temperature. [2] However, silicon nitride is an insulator, and adding a metal electrode layer on top of a silicon nitride beam degrades the quality factor. [3] In contrast, graphene is a semi-metal, capable of detecting its own motion, and can be tuned by a factor of two with an electrostatic gate. However, graphene membranes have poor quality factors at room temperature[4,5]

In this work, we use a large-scale method to fabricate layered graphene and silicon nitride heterostructures as doubly clamped beams, as shown in Figure 1. Also, novel dry stamping technique is implemented in transferring graphene onto substrate to allow accurate placement. We use optical techniques to drive and detect mechanical resonance for devices from 3-20 um in length. We find the room temperature quality factors of the heterostructures as ~2000-8000 as shown in Table 1, compared with quality factors of ~20000-30000 for bare silicon nitride devices, and ~ 50-1000 for single layer graphene membranes. In addition, the frequency change from bare nitride resonators is found to be negligible. This result indicates that the graphene can be an excellent material to use to metalize insulating NEMS materials. Future work will enable direct electrical detection of graphene-nitride resonators with high signal-to-noise ratio[6] and high tuning range.

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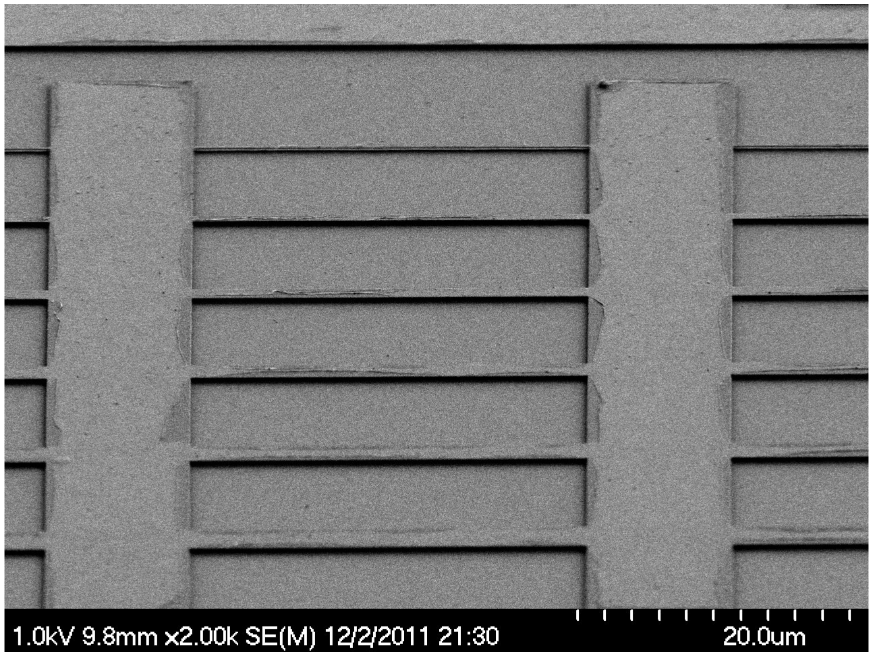

Figure 1: Suspended silicon nitride-graphene resonator array with variation in resonator width and length. The thickness of silicon nitride is 60nm, and the strip is 280nm above the substrate. Graphene is shown to be bright where silicon nitride is shown to be darker.

	Length (um)	**8**	**9**
Silicon Nitride Only	Q	28000	30000
	F (MHz)	30	27
Silicon Nitride Graphene Stack	Q	2700	7500
	F (MHz)	32	28

Table 1: Comparison for the optical measurement results for silicon nitride resonator and silicon nitride-graphene stack resonator.