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GRAPHENE MECHANICAL RESONATORS FOR CIRCUIT QED

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Graphene, a single atomic layer from graphite [1], is an ideal candidate for nanoelectromechanical applications due to its large Young's modulus and low density. We have developed a micromanipulation technique to fabricate mechanical resonators [2, 3] out of suspended graphene. The fabrication steps are illustrated in Fig. 1a, where the graphene sheet is suspended using a PMMA stamp and positioned on top of a prefabricated gate electrode. The resonator is actuated with a high frequency ac signal applied to the gate, and the reflected sideband signal is detected to find the mechanical resonance [4] of the graphene (Fig. 1b).

Mechanical resonances of multilayer graphene and monolayer graphene samples have been detected. Fig. 2a shows the resonance frequency of a multilayer graphene sample with a biquadratic dependency on the DC bias voltage. The highest resonance frequency ($\sim$178MHz) detected so far on monolayer (L = $\sim$0.5 μm) graphene sample measured at 4 K is shown on Fig. 2b.

Further increase in frequency could be reached by utilizing a low-capacitance oscillator schematic (Fig. 1c). In this scheme, the electrical resonant circuit effectively eliminates the external wiring capacitances. Resonance at 6.7 GHz has been detected in such a scheme without graphene capacitor.

Our fully electrical detection method is applicable for nanoscale mechanical resonators in a large frequency range. The fabrication method is promising to build more complex nanoelectromechanical systems from graphene or carbon nanotubes [5].

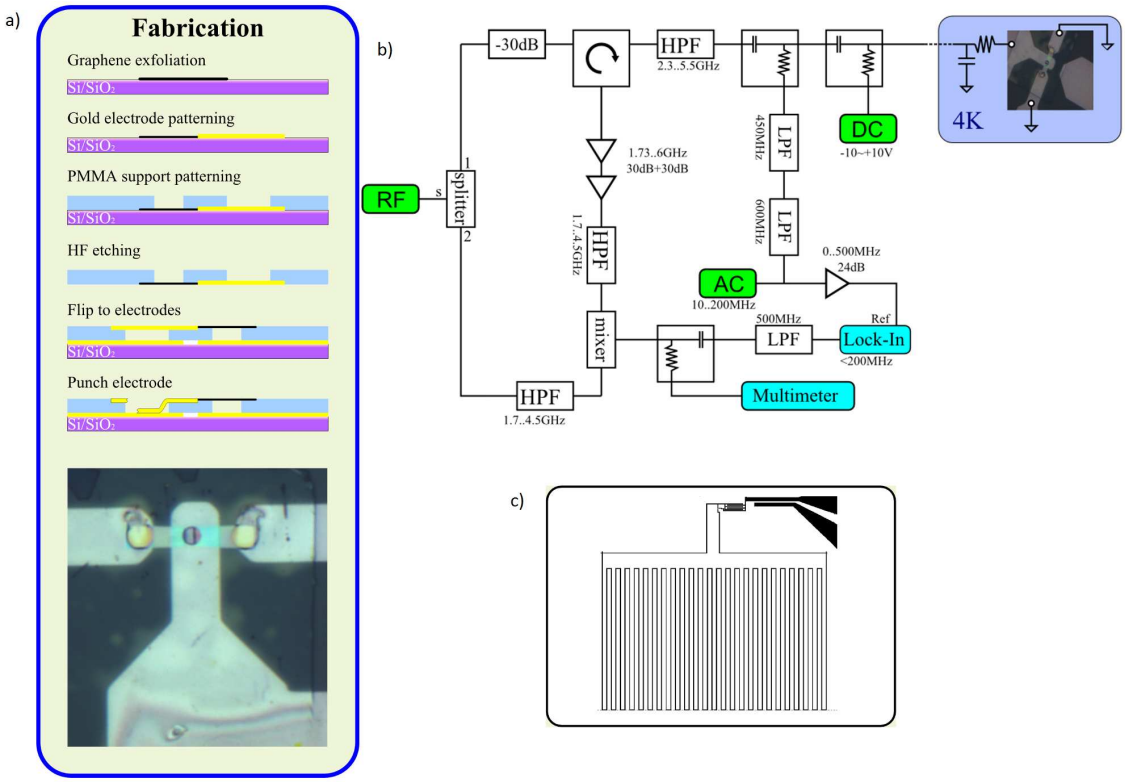

Figure 1: a) Fabrication steps of the graphene resonator. b) Reflection measurement scheme for sideband detection. c) Further increase in resonance frequency and Q value can be achieved using an on-chip LC circuit to eliminate wiring capacitances.

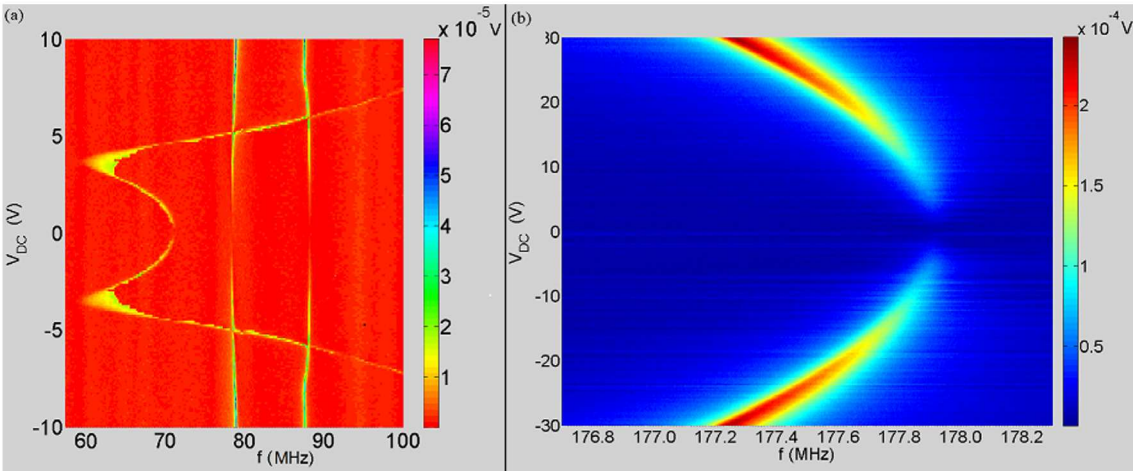

Figure 2: a) Biquadratic resonance versus gate voltage of a multilayer graphene resonator. b) Highest resonance frequency of a monolayer graphene resonator. Both samples were measured at 4 K.

References

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