Demonstration of Suspended Graphene Varactors

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Abstract

The high yield strength, low flexural rigidity and low mass density of suspended graphene membranes are potentially promising for nanoelectromechanical applications [1]. Here we present a theoretical analysis and experimental demonstration of suspended graphene varactors, where capacitance is tuned by electrostatic actuation of membrane deflection. Due to their atomic layer thinness, graphene membranes exhibit non-Hookean deflection, creating a capacitor tuning range of ~75% compared to 50% for traditional Hookean parallel plate varactors[2]. The low flexural rigidity of graphene membranes enables low membrane pull-in voltage. This approach has higher linearity of the capacitance change with voltage near zero bias owing to amibolar pull-in characteristics, and a simple structure. In contrast, silicon parallel plate varactors usually employ complex techniques to improve tuning range and linearity while maintaining a low pull-in voltage [3,4].

We fabricated varactors by transferring a pre-patterned graphene membranes grown by chemical vapour deposition to an oxidized silicon substrate pre-patterned with gold contacts and trenches for graphene suspension, as shown in Figure 1. Critical point drying was used to release the graphene membranes. The capacitance versus DC bias voltage of varactors were measured with the samples under vacuum using standard lock-in techniques at a frequency f = 100 kHz. Experimental measurements agree well with our thin-plate model [2] with a Young's modulus of E = 0.25 TP and a pre-tension S = 0.06 N/m as depicted in Figure 2. The corresponding pull-in voltage of our devices is V_π = 13 V, and full ambipolar behaviour is observed. Further work is required to improve manufacturability, integration with silicon and lifetime of graphene membranes for future varactor applications.

References

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Figures

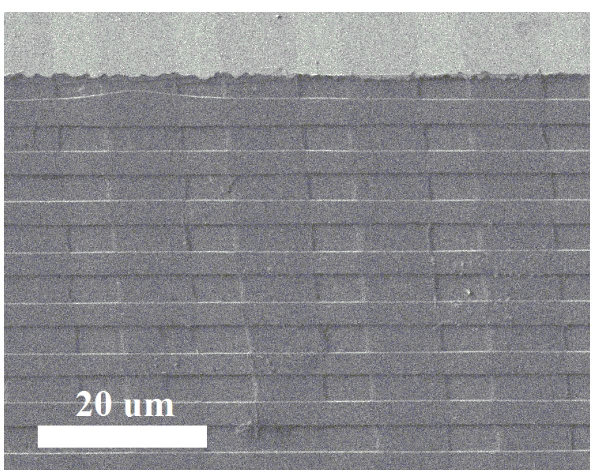

Figure 1: SEM image of graphene varactor structure with graphene membranes suspended over trenches in an oxidized silicon substrate

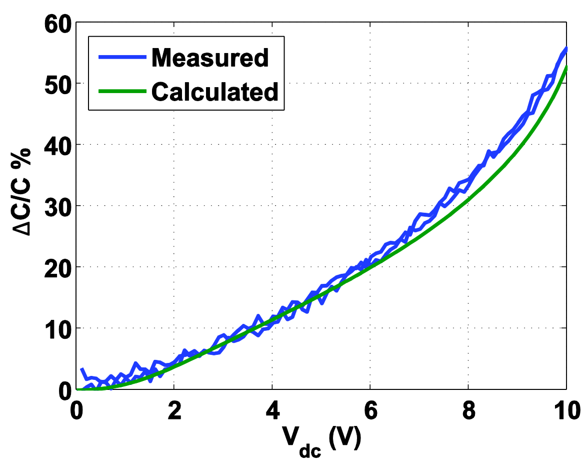

Figure 2: Measured and theoretically modelled relative change in capacitance versus applied DC voltage. Measurements were made at f = 100 kHz and under vacuum. The model includes S = 0.06 N/m and E = 0.25 TP, corresponding to V_{pi} = 13 V