Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Effect of Strain on the Mechanical and Transport Properties of Graphene

By

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The structural flexibility of low dimensional nanomaterials offers unique opportunities for studying the impact of strain on their physical properties and for developing innovative devices utilizing strain engineering. Among these materials, graphene is the most robust one with large breaking strain, low mass density and ultra-high mobility. In this thesis, the effect of strain on the mechanical and charge-transport properties of graphene is studied using Field Effect Transistor like Graphene Nano-Electro-Mechanical Resonators (FET-like GNEMRs) on flexible substrates. The device and instrument setup designed in this work allow independent tuning of strain in graphene through bending the substrate.

The first part of this thesis explores the nonlinear dynamics of the GNEMRs over a wide parameter space. A non-monotonical dependence of resonant frequency on strain and a transition from hardening to softening behavior are observed in the resonance characterization. Analytical and numerical studies using a continuum mechanics model, including the competing higher order nonlinear terms, reveal a comprehensive phase diagram of the nonlinear dynamics, which quantitatively explains the complex behavior of GNEMRs. The resonance characterization also gives a reliable calibration of the strain in graphene.

The remaining part of this thesis focuses on the effect of uniaxial and shear strain on the charge-transport properties of single layer graphene. Strain-dependent gating effect is observed. The effect is closely related to the ripple scattering mechanism in graphene, which varies with strain. Possible application of this device platform in studying other low dimensional nanomaterials, such as multi-layer graphene and black phosphorous is also discussed.

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