

**Stony Brook University
The Graduate School**

Doctoral Defense Announcement

Abstract

Bolometric effect and phonon cooling in graphene-superconductor junctions

By

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Graphene, a two-dimensional allotrope of graphite, possesses remarkable electronic properties which stem from the fact that the electrons in graphene are described by the Dirac-Weyl Hamiltonian. As a result, graphene exhibits a linear energy dispersion relation with zero effective mass. With its single-atomic-layer thickness, not only electrons but also phonons are of a two dimensional nature, differentiating graphene from the conventional semiconductor based two-dimensional electron gas systems. The combination of two-dimensional phonons, ultra small volume, low density of states and linear energy spectrum allows graphene to have weak electron-phonon coupling and extremely small electronic specific heat. These properties make it a desirable material for use in a bolometer device, which is a sensitive electromagnetic radiation detector.

We present a novel device design, which combines graphene with superconducting contacts and investigate its bolometric response. Two configurations of superconductor (S)-graphene(G)-superconductor(S) Josephson junction (SGS) and superconductor(S)-insulator(I)-graphene(G) (SIGIS) tunnel junction are studied. Devices with aluminum, niobium and niobium nitride as superconducting contacts are studied. In SIGIS tunnel junctions, titanium oxide is used as the barrier oxide to achieve high efficiency impedance matched bolometers. In these devices, "hot electrons" are created via application of microwave radiation and their relaxation to the bath temperature is studied. With the hot electrons effectively confined by the superconducting contacts, we demonstrate electron cooling via phonon interactions. This device geometry allows to study electron-phonon coupling in single and bilayer graphene at low temperatures. In single layer graphene, a disorder modified temperature dependence of electron-phonon cooling power is observed. And in bilayer graphene, it is shown that the electron-phonon coupling parameter has an inverse dependence on the chemical potential, opposite to that found in single layer graphene.

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