TUNING THE ELECTRICAL PROPERTIES OF LARGE AREA GRAPHENE THROUGH BORON-NITROGEN CO-DOPING

B. Muchharla[1], A. Pathak[1], Z. Liu[2], L. Song[2], S. Kar[3], R. Vajtai[2], P. M. Ajayan[2], S. Talapatra[1], N. Ali[1]

[1]Department of Physics, Southern Illinois University Carbondale, IL-62901
[2]Department of Physics, Rice University, Houston, TX-77054
[3]Department of Physics, Northeastern University, Boston, MA-02115

The effect of impurities on the physical properties of materials with an otherwise perfectly crystalline order have intrigued scientist for decades. In this respect, the availability of 2D layered materials such as graphene and the ability to introduce structural imperfections in them through doping has opened up possibilities for studying the consequence of disorder at the atomic level. In this study, we report on investigation of low temperature electrical transport measurements of B and N co-doped graphene layers C(B,N). These systems have a unique combination of impurities including both atomistically separated B and N species, as well as hexagonal boron nitride (*h*-BN) units within the graphitic C lattice. Despite its graphene-like lattice structure, *h*-BN is a wide band-gap material (>4.5 eV) due to a breakdown in its sublattice mirror symmetry. Hence, asymmetrically co-doped C(B,N) with $n_B \neq n_N$, is a unique combination of impurity doping and alloy formation within a 2D confined geometry. Earlier, the presence of *h*-BN it has been shown to open up a band gap in the otherwise gap-less graphene. In this work, we present a detailed investigation of the temperature dependence of transport in asymmetrically co-doped C(B,N). We find that the temperature dependence of resistance ($5K < T < 400$ K) of pure graphene shows a metallic behavior, whereas the C(B,N) samples show an increasingly semiconducting behavior with increasing doping levels. The temperature dependence of these samples could be approximately classified into two regimes. Within the studied range, at higher temperatures, the doped samples showed a band-gap dominated Arrhenius-like temperature dependence. At the lowest temperatures, the temperature dependence deviates from an activated behavior, and presents evidence for a conduction mechanism that is consistent with Mott's 2D-Variable Range Hopping (2D-VRH).