Abstract

The experimental discovery of graphene in 2004 has opened up a new research field in the direction of atomically thin two-dimensional layered materials for exploration of many fundamental research problems and technological applications. The charge carriers in graphene are massless Dirac fermions due to which they exhibit absence of localization, thereby giving rise to huge intrinsic mobilities and ballistic transport even at room temperatures. But it was observed that the extrinsic disorder and intrinsic structural disorder can significantly influence the transport in graphene films. This thesis focuses on three different aspects of graphene - disorder, magnetism and proximity-induced superconductivity. We have reported conductance fluctuations-based transport studies to investigate these aspects as they provide more detailed information than what can be obtained from the standard transport measurements. Even though these conductivity fluctuations pose a serious bottleneck for various applications, they can also yield useful insights into the various scattering mechanisms and the symmetry properties of graphene.

In the first half of the thesis, we describe the measurement of low frequency 1/f noise in large area polycrystalline graphene films to understand the role of grain boundaries in charge carrier transmission in graphene. TEM studies on the low and high angled GBs formed in these graphene samples showed that they form distinct disordered regions of varying widths depending on the tilt angle of the GBs. At low temperatures, the 1/f noise measurements indicated spontaneous breaking of time reversal symmetry across graphene grain boundaries which suggests the magnetic nature of these grain boundaries. In the second half of the thesis, we will concentrate on the universal conductance fluctuations (UCF) in graphene which is the manifestation of quantum interference phenomena at low temperatures. We find that the absolute magnitude of the UCF is directly related to various symmetry-breaking disorder present in graphene. We also discuss how the UCF can be used to study the nature of proximity-induced superconducting correlations in graphene. In the end, we have proposed new device schemes for the integration of ferromagnetic and superconducting materials with graphene.