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Rectification at graphene-semiconductor interfaces[1]

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It is now widely recognized that interface between graphene and many semiconductors forms Schottky barriers with rectifying properties. Our work in this area at the University of Florida began in 2009 with our discovery that bulk semimetal graphite when simply pressed against Si, GaAs and 4H-SiC semiconductor substrates readily formed Schottky barriers. Since graphite comprises Bernal-stacked layers of graphene, then the outermost layer, a single sheet of graphene, in contact with the semiconductor plays a major role in the formation of the Schottky barrier. In this talk we follow up on this early work and report on the unusual physics and promising technical applications associated with the formation of Schottky barriers at the interface of graphene and conventional semiconductors. Much of the phenomenology is similar to what is seen with graphite/semiconductor Schottky barriers but with the additional advantages that graphene is flexible, transparent and has a Fermi energy that can be more easily tuned either positively or negatively with respect to the neutrality point by electric fields or chemical doping. Our junctions are fabricated by mechanically transferring chemical vapor deposited graphene onto n-type Si, GaAs, 4H-SiC or GaN semiconductor substrates and takes advantage of the strong van der Waals attraction that is accompanied by charge transfer across the interface and the formation of a rectifying (Schottky) barrier. Using current-voltage (I-V), capacitance-voltage (C-V) and Raman measurements we find that thermionic emission theory in conjunction with the Schottky-Mott model within the context of bond-polarization theory provides a surprisingly good description of the electrical properties. We will discuss a number of applications including diode operation to temperatures as high as 550 K, hole doping and associated Fermi level shifts induced by overcoating the graphene with a transparent layer of polymer (TFSA), and demonstration of solar cells with power conversion efficiencies approaching 9%.

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