A11: New perspective on the 2D metal-Insulator Transition

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The discovery of low-dimensional metallic systems such as high-mobility metal oxide field-effect transistors, the cuprate superconductors, and graphene, silicene, phosphorene, conducting oxide interfaces (*e.g.*, $LaAlO_3/SrTiO_3$), and a large variety of transition metal chalcogenide and dichalcogenide systems contradicts the seminal theory for transport in disordered metals that predicts that the metallic state cannot exist in two dimensions (2D).[1] A key issue in such studies is the nature of the metal insulator transition (MIT) in 2D. Since the MIT is a quantum phase transition (one that occurs at T=0K) the transport properties should be independent of the chemical and structural details of the system. In this presentation, we will demonstrate that a generic phase diagram for the 2D MIT can be constructed for two very different systems: 1) highly disordered RuO_2 nanoskins and 2) plasma-functionalized graphene. This phase diagram consists of three regions: metallic, weakly localized insulator with conductivity, $\sigma \sim \log T$, and strongly localized insulator. We will present details of the transport properties of the disordered RuO_2 nanoskins and plasma-functionalized graphene near their respective MITs.

Reference

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A12: Electron Spin at Work in Modern and Emerging Devices

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The continuous increase in performance of modern integrated circuits has been constantly supported by the

miniaturization of electronic components and interconnects. Although the feasibility of the 7nm technology node was recently demonstrated [1], fabrication costs, control, and integration combined with reliability issues will gradually bring the metal-oxide-semiconductor field-effect transistor (MOSFET) scaling to an end. The MOSFET operation is fundamentally based on the charge of an electron interacting with the gate potential, which allows controling the current flow in the channel between source and drain, which makes it a charge-based approach (i.e. electrical current) and thus ultimately consumes electrical power. To reduce power consumption, the electron spin is considered as a potential candidate for building innovative devices complementing or even replacing the conventional charge-based electronics as it allows to introduce non-volatility in the device operation and opens a way to reduce the dependence on charge transport, i.e., to significantly reduce power consumption. The spectacular experimental demonstration of a SpinFET [2] - predicted 25 years ago [3] - brings semiconductor spintronics closer to applications.

In order to realize a SpinFET, three fundamental ingredients are required: efficient spin injection/detection, spin propagation, and spin manipulation by purely electrical means [3,4]. In silicon, however, the gate voltage-dependent spin manipulation is overshadowed by a weak spin-orbit interaction [4,5]. Regardless of the weak interaction, it results in a finite probability for a spin flip at every electron scattering event, which leads to the injected spin relaxing to its equilibrium zero value. Because in thin silicon films the spin relaxation is mostly determined by scattering between the equivalent valleys, the spin lifetime is significantly enhanced by uniaxial stress [6] as it efficiently lifts the degeneracy between these valleys. Since the spin-orbit field acts in-plane, the spin lifetime can be further boosted by a factor of two for in-plane injection as compared to the injection orthogonally to the film [7]. The spin lifetime in silicon films can be engineered to guarantee the spin propagation at distances (about a micrometer), which is sufficient for practical applications. For spin injection in silicon within the three-terminal injection scheme the respective signal appeared to be orders of magnitude larger than the theory predicts [8]. Although magnetoresistance due to spin-dependent resonant tunneling [9] is likely responsible for the large signal, the reason for the discrepancy is under scrutiny [10]. To add to the controversy, a different expression for magnetoresistance was recently suggested [11]. To resolve the discrepancy, a numerical Monte Carlo approach for the spin- dependent trap-assisted tunneling in tunnel junctions was developed [12]. We demonstrate that the spin-dependent tunneling rates are determined by the two spin-up/spin-down levels considered in [11] only if the magnetic field is parallel to the

magnetization. In a general case all four eigenvalues of a 4×4 transition matrix must be considered, which explains the controversy [12].

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A13: End states of rectangular armchair graphene ribbon

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We consider the end states of a half-filled rectangular armchair graphene ribbon (RAGR) in a staggered potential (see Fig.1). Taking electron-electron interactions into account we find that, as the strength of the staggered potential varies, three types of couplings between the end states can occur: antiferromagnetic without or with spin splitting, and paramagnetic without spin-splitting. We find that a spin-splitting is present only in the staggered potential region $0 < \Delta < \Delta_c$. The transition from the antiferromagnetic state at $\Delta = 0$ to the paramagnetic state goes through an intermediate spin-split antiferromagnetic state, and this spin-splitting disappears suddenly at Δ_c. For small and large values of Δ the end charge can be connected to the Zak phase of the periodic armchair graphene ribbon (PARG) with the same width, and it varies continuously as the strength of the potential changes.