Electronic Properties of Nanodiamond in the Quantum Regime

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Low-cost lab-grown diamond is increasingly being recognized as a piece of jewelry for science and technology, due to its unique intrinsic properties such as the extraordinarily high thermal conductivity and robustness and wide-ranging electronic properties. Upon boron doping, insulating intrinsic diamond becomes a semiconductor when lightly doped and a superconductor when heavily doped, respectively [1]. Diamond field-effect transistors and microelectro-mechanical radio frequency switches have been demonstrated to be superior candidates for high-power highs-peed devices. Apart from being used to refine traditional electronics, diamond also provides a powerful platform for unveiling new quantum phenomena for the development of quantum electronics and magnetoelectronics [2-4].

To maintain the low fabrication cost, diamond thin films are generally grown on non-diamond substrates, and thus are polycrystalline and have a granular structure [5]. Based on the data of electrical transport and direct local measurements, I will demonstrate the influence of the nanoscale granularity on the electronic properties of this material [6]. A series of intriguing bosonic anomalies, such as the bosonic insulating state and anisotropic superconductivity [2,3,7-9], will be interpreted in the framework of the quantum confinement and coherence of single quasiparticles and Cooper pairs in the presence of granular disorder. Our data unveil the percolative nature of the electrical transport in nanodiamond films and reveal the essential role of grain boundaries in determining the electronic properties of this material. The physics, which we extracted from nanodiamond, can be applied to other granular electronic materials.

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