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Diamond Surface Functionalization and Doping for Carbon-based Electronics

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Despite being a bona-fide bulk insulator, the surface of diamond presents a versatile platform for exploiting some of the extraordinary physical and chemical properties of diamond, leading to applications such as chemical/biological sensing and the development of high-power and high-frequency field effect transistors (FETs) [1]. On one hand, bare diamond (001) surfaces are reactive, and can be readily functionalized by organic molecules through chemical reactions such as cycloaddition reaction. Hydrogen-terminated diamond surface, on the other hand, develops an intriguing two-dimensional (2D) *p*-type surface conductivity when exposed to appropriate surface adsorbate layer such as atmospheric water as a result of the surface transfer doping process.

In the first part of the talk, I will describe our recent work in the engineering of diamond surface properties through surface functionalization [2]. The implications of these new diamond surface terminations to potential applications in photochemistry and quantum sensing will be discussed. In the second part of the talk, I will describe our work on the surface transfer doping of diamond by a variety of solid-state acceptors [3]. I will show that by interfacing diamond with suitable materials a 2D hole conducting layer with metallic transport behaviours arises on diamond. Magnetotransport studies at low temperature reveal phase coherent transport in the 2D channel represented in the form of weak localisation and antilocalisation, and are analysed in the context of spin-orbit coupling induced by Rashba effect. We also demonstrate that this surface conducting channel can be exploited to build diamond surface electronic devices such as metal-oxide semiconductor FETs (MOSFETs). Lastly, the prospects for constructing novel quantum devices on diamond surface by making use of this highly tunable 2D conducting layer on diamond are also explored.

References:

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