Tuneable space-charge-doping for scanning tunnelling microscopy investigations

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Doping dependency of 2D materials has in recent years caught much attention, as doping can induce novel physics, such as insulator to superconductor transitions [2] and new charge density wave phases. The nature of these phases is not fully understood, and an in-depth study of tuneable doped systems is therefore of high interest. Scanning tunnelling microscopy (STM) provides the perfect tool to investigate and analyse these novel phases with the ability to resolve structural and electronic properties at an atomic scale. The newly emerged technique, space-charge-doping (SCD) [1], has been found to provide extremely high doping levels ($> 10^{14}$ cm^{-2}), high tunability while preserving the high surface quality necessary for STM without having any of the downsides of the standard doping methods. This project aims to study doping dependent behaviour of 2D materials through STM and the SCD method. Through the anodic bonding technique, we bind few-layer crystal flakes to a glass wafer. This technique automatically induces electrostatic doping of the flakes through space-charge-doping. Once bound to the glass wafer, the doping level of the flake can be tuned freely and repeatedly through reheating of the glass while applying various electric fields. This is the basis of the SDC method. The combination of SCD and STM allows us to study the same sample at multiple doping levels, providing valuable insight into the nature of purely doping induced phases at the atomic level.

[1] Andrea Paradisi, Johan Biscaras, and Abhay Shukla , "Space charge induced electrostatic doping of two-dimensional materials: Graphene as a case study", Applied Physics Letters 107, 143103 (2015).
[2] Johan Biscaras, Zhesheng Chen, Andrea Paradisi and Abhay Shukla "Onset of two-dimensional superconductivity in space charge doped few-layer molybdenum disulfide", Nature Communications 6(1): 8826 (2015).