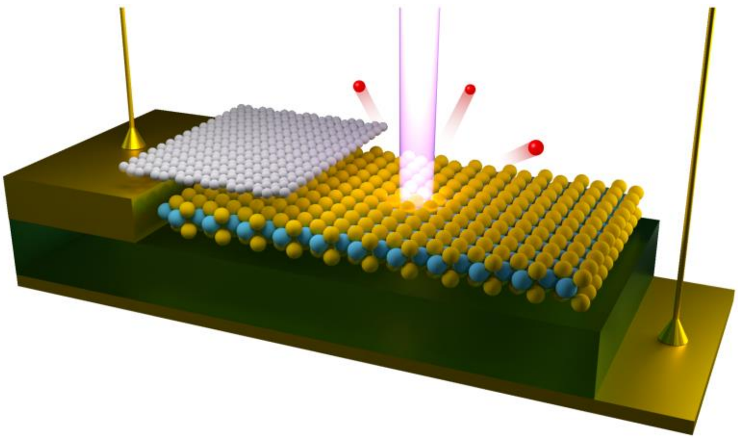
Band structure measurements in van der Waals heterostructures

Project supervisor: Dr Neil Wilson (neil.wilson@warwick.ac.uk)

Angle resolved photoemission spectroscopy (ARPES) beautifully reveals the momentum-resolved electronic structure at the surface of crystalline solids. The spectra have both fundamental and technological relevance, giving insight into many-body phenomena, providing parameters essential to electronics, and with a natural link to first principles calculations. Spatially-resolved ARPES with submicrometre resolution (nanoARPES) opens the tantalising possibility of interrogating microelectronic devices and directly comparing band structure changes to optical and transport measurements. We have recently demonstrated such in-operando band structure measurements for the first time [Nature, 572(7768), 220–223. (2019)], revealing new insight into many-body effects in two-dimensional van der Waals heterostructures (vdW-HSs).

vdW-HSs are built, with atomic precision, by stacking atomically thin layers of 2D materials to design new materials and engineer new phenomena. Band structure measurements in these systems are essential to reveal the layer-dependent electronic structures that determine the novel optical and electrical properties of the stacks. With increasing interest in recent years in topological and strongly correlated materials including 2D magnets, the ever increasing diversity of 2D materials has dramatically expanded the range of structures and Physics to be explored. Integration with existing technologies, such as ferroelectrics, presents new opportunities for agile control over electronic structure. And there are fascinating opportunities for quantum ‘twistronics’, engineering new electronic phenomena through controlling the relative orientation of the layers. There is scope to explore all of these areas, but the focus of this project will be on band structure measurements whilst varying control parameters such as carrier concentration, electric field, inter-layer coupling, dielectric environment and strain.

Funding (stipend plus fees) is available for exceptional UK and EU candidates for 3.5 years, with a stipend at the standard research council rate. Applicants with interest in condensed matter Physics and aptitude for experiment and data-analysis are encouraged to apply. Applicants should be willing to travel as measurements will be taken at international central facilities.



Schematic of photoemission from a vdW-HS with integrated back-gate electrode for in situ carrier concentration dependent ARPES measurements.