Revealing the atomic-scale mechanisms for next-generation memory – the 2D 'atomristor'

As we now approach the end of the road for the miniaturisation of conventional silicon devices, new "beyond Moore" device types are required to allow for continued advances in computing power. A core component of a computer is the memory, for which we ideally want a device that offers quick performance, high storage density, and non-volatility (i.e., it still 'remembers' when depowered). The need for such memories are even more necessary now, with emerging data-intensive applications from drug development to AI learning datasets.

The 'atomristor' is a memory based on the memristive switching of a 2D material, such as hexagonal boron nitride or molybdenum disulfide, and promises to offer all of the properties needed in an ideal memory component. Memristive switching is the reversible toggling between a high and a low resistance state, which can be used as a means of storing data. Unfortunately, the atomic level mechanisms behind this switching in 2D materials is only partly understood, with the interlinked role of atomic defects, the formation of the atomic 'filament', and how these all evolve over repeated cycles, still remaining unclear. To solve this we need to image a functional device at the atomic level while it is being operated.

This PhD project will use our state-of-the-art atomic resolution imaging facilities to expose these single-atom processes as they occur in working 2D material memristors, the understanding of which are crucial for us to realise these devices in practical applications. We will use transmission electron microscopy (TEM) to directly image these atomic transitions in real-time, and also use the electron beam to perform nanoscale tailoring of defects into the device structure to elucidate their role.

Alongside TEM imaging, you will fabricate these stacked 2D material devices in our semiconductor fabrication cleanroom, and in the process learn how to prepare and handle 2D materials. There are opportunities for you to engage with international collaborators with partners in the USA and Korea.

This project is suited to a student with interests in condensed matter physics, materials science, and nanotechnology. If you are interested in this project please contact me at alex.w.robertson@warwick.ac.uk.