Project: Scanning Probe Fabrication and Readout of Atomically Precise Silicon Quantum Technologies

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Abstract: While quantum technologies have captured the imagination of scientists and technologists alike, the ideal candidate material for scalable future quantum computers, namely silicon, remains largely untapped. In this project the student will fabricate many silicon qubits from foreign 'dopant' atoms in silicon. They will adapt a unique dopant placement capability developed at UCL to make large random distributions of single dopant atoms or a few precisely placed dopants, or a combination of both, in a 2D plane in silicon. In order to use these dopant distributions as a source of many qubits, the student will work with Nanolayers to assess scanning tunnelling microscopy images of the surface using machine learning image recognition to locate the dopants. Subsequently they will collaborate with McGill University who will use their (also unique) atomic force microscopy technique that performs single electron spectroscopy on individual dopant atoms. With this spectroscopy the electronic properties of the dopant atoms as well as the quantum mechanical coupling between them as a function of separation will be measured. With thousands of dopants characterised, the most suitable can be chosen to be converted into qubits. The final stage of fabricating qubit device structures from a known dopant distribution is currently performed completely manually and cannot be scaled up to more than a few qubit bits at most. However, using newly developed methods by Nanolayers to train transferrable automation AI, fabrication will be scaled-up to many qubits, pushing silicon to the forefront of the quantum information revolution.