The importance of atomic precision for realising quantum processors in silicon

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The realisation of a large-scale error corrected quantum computer relies on our ability to reproducibly manufacture qubits that are fast, highly coherent, controllable and stable. The promise of achieving this in a highly manufacturable platform such as silicon requires a deep understanding of the materials issues that impact device operation. In this talk I will demonstrate how we engineer every aspect of the processor using atom qubits in silicon for fast, controllable exchange coupling [1], fast, high fidelity qubit initialisation and read-out [2]; low noise all epitaxial gates for highly stable qubits [3,4]; and efficient, high fidelity qubit control [5,6] leading to the demonstration of the highest fidelity Grover's algorithm to date [7].

I will also discuss our latest results in quantum analogue processors. Here I will present an atomically engineered quantum feature generator in which we use quantum states to increase the accuracy of classical machine learning [8]. I will also show our latest results in analogue simulation [9,10] realising Feynman's dream of directly simulating materials by the atomic precision placement of atoms in silicon.

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