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Photo-Induced Current Transient Spectroscopy of Si/SiO_2 Interface Defects in High-Resistivity Silicon

Silicon metal-oxide semiconductor (MOS) device structures are vital for realizing quantum computing devices based on single atoms acting as qubits in silicon. These atoms must be located within ˜20 nm of the Si/SiO2 interface to allow proper operation of control electrodes and read-out structures. [1] Qubits store quantum information in electron–nuclear spin states, which are highly sensitive to fluctuating electric and magnetic fields arising from nearby charge and spin defects. Therefore, probing the Si/SiO2 interface quality is crucial, as environmental interactions can induce decoherence. High-resistivity silicon substrates are essential for quantum applications because they minimize parasitic conduction and electromagnetic losses [2]. To study defect states in such substrates, we perform photo-induced current transient spectroscopy (PICTS) on simple source–drain devices implanted with low fluences of Er, H, and P ions. Measurements were carried out using a 780 nm laser diode over a temperature range from 300 K down to 86 K. PICTS probes photo-conductivity decay as a function of temperature, revealing generation–recombination processes in highly resistive semiconductors. This non-invasive technique has high sensitivity to oxide and bulk defects and only requires two ohmic contacts diffused through a layer. As an optically driven technique, PICTS can probe defects at cryogenic temperatures below 4K with photon pulses being used to excited charge carriers across the bandgap to circumvent the carrier freeze-out that occurs at these low temperatures. [3]

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Field of Condensed Matter

Quantum Materials

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