Nuclear spin-free ^{70}Ge/^{28}Si^{70}Ge heterostructures for hole spin qubit applications

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Spin qubits based on germanium (Ge) heterostructures are frontline candidates for quantum processors with long coherence times [1-3]. This is in part due to the advantages of hole spins in Ge, such as their large spin orbit interaction and reduced hyperfine coupling with nuclear spins [4-6]. As hole qubits in planar Ge heterostructures are very sensitive to the nuclear spin environment [7], fabricating and characterizing structures devoid of such nuclear spins has become a recent objective of the quantum semiconductor research community.

We have recently demonstrated highly crystalline, defect free, isotopically purified (>99.9 at.% ^{70}Ge) nuclear spin-depleted ^{70}Ge quantum well (QW) heterostructures grown in a reduced pressure CVD using purified precursors (>99.9 at.% $^{70}GeH_4$ and >99.99 at.% $^{28}SiH_4$) [8]. The quantum wells consist of a series of ^{70}Ge/SiGe heterostructures grown on Si wafers using a Ge virtual substrate and a graded SiGe buffer layer (Fig. 1(a)) with progressively purified and thick layers. The isotopic purity of the structures was established with atom probe tomography to be over 99% for our fully purified sample (Fig. 1(b)). The nuclear spin background in the quantum wells was found to be sensitive to the growth conditions.

Our ongoing work in this field focuses on the optimization of the interface structure, transfer to established buffers by homoepitaxy and defect control in the barrier and well. Additional details concerning the fabrication of heterostructures with $Si_{20}Ge_{80}$ and $Si_{30}Ge_{70}$ barriers, surface preparations for epitaxy and details concerning the purity and spin depletion of the QWs will be discussed at ICPS2024.

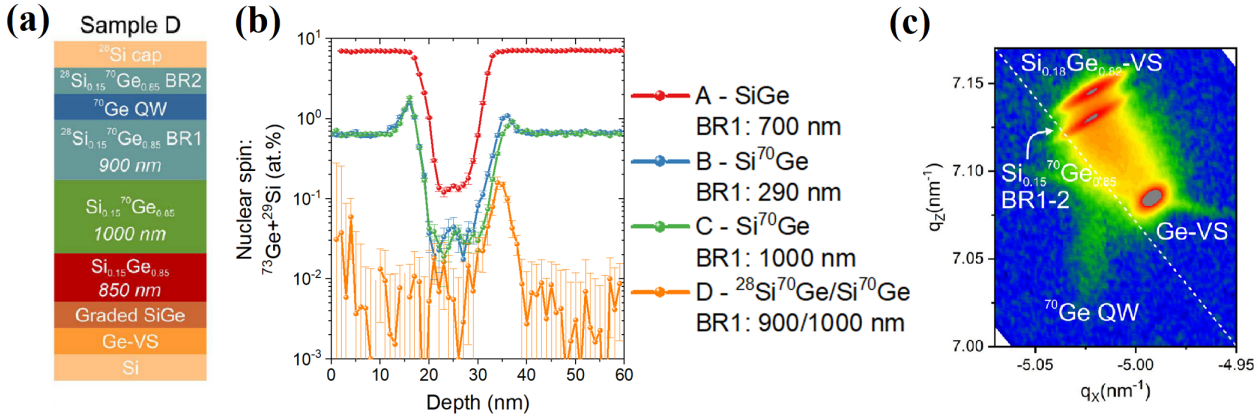

Fig. 1. Schematic representation (a), nuclear spin content (b) and ($\bar{2}\bar{2}$4) RSM results (c) of the purified ^{70}Ge QW structures.

References

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