Contribution ID: **101** Type: **Poster**

Hyperdoped superconducting Ge for quantum technology

Monday, 16 May 2022 18:50 (1h 10m)

Superconductivity in group IV semiconductors is desired for hybrid devices combining both semiconducting and superconducting properties. Following boron-doped diamond and Si, superconductivity has been observed in gallium-doped Ge; however, the obtained specimen is in polycrystalline form [Phys. Rev. Lett. 102, 217003 (2009)]. Here we present superconducting single-crystalline Ge hyperdoped with gallium or aluminum by ion implantation and rear-side flash lamp annealing. The maximum concentration of Al and Ga incorporated into substitutional positions in Ge is 8 times higher than the equilibrium solid solubility. This corresponds to a hole concentration above 1021cm−3. Using density functional theory in the local-density approximation and pseudopotential plane-wave approach, we show that the superconductivity in p-type Ge is phonon mediated. According to the ab initio calculations, the critical superconducting temperature for Al- and Ga-doped Ge is in the range of 0.45 K for 6.25at.% of dopant concentration, being in qualitative agreement with experimentally obtained values. Being Si-chip technology compatible, superconducting Ge can find wide applications in quantum technology.

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Session Classification: POSTER SESSION 1