## Group IV Planar Heterostructures Reimagined

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Group IV semiconductors underpin a vast range of photonic and spin-based technologies, owing to their compatibility with mature silicon platforms, scalable fabrication, and the unique ability to engineer their isotopic composition. State-of-the-art quantum and nanoelectronic devices largely rely on silicon and germanium, exemplified by electron spin qubits in Si/SiGe heterostructures and hole spin qubits in Ge/SiGe systems. While these platforms have demonstrated remarkable coherence and controllability, their intrinsic material properties impose limitations on optical functionality and band structure tunability. In this presentation, we explore the emergence of germanium-tin (GeSn) and related tin-based group IV alloys, focusing on their integration into low-dimensional systems to enable advanced strain engineering, bandgap tuning, and control over bandgap directness. Specific examples of engineering the valence-band character (light-hole versus heavy-hole) in optically active heterostructures will be presented. We discuss recent progress in developing growth strategies that stabilize high-quality GeSn-based heterostructures compatible with silicon substrates. Additionally, we highlight advances in isotopic purification in group IV semiconductors. Particular attention is given to methodologies for achieving high isotopic purity in low-dimensional systems and to characterization approaches that avoid measurement artifacts. Together, these developments establish emerging group IV heterostructures as a versatile platform that combines isotope control, bandgap engineering, and silicon integration to enable the next generation of quantum and photonic devices.