

Quantum confinement and strain effects in Ge/SiGe quantum wells

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Germanium-silicon-germanium (Ge/Si_xGe_{1-x}) heterostructures are an emerging group-IV platform for quantum devices, high-mobility electronics, and hybrid superconductor-semiconductor architectures. In these systems, strain, quantum confinement, and spin-orbit coupling strongly reshape the valence-band structure of Ge quantum wells, thereby defining the electronic properties of low-energy hole states. However, the momentum-resolved electronic structure of buried strained Ge quantum wells has so far only been inferred indirectly. Here we use soft X-ray angle-resolved photoemission spectroscopy (SX-ARPES) to directly probe strained Ge quantum wells embedded in SiGe barriers [1]. We resolve strain-split and size-quantized valence subbands, identify their heavy-hole, light-hole, and split-off character, and determine the valence-band offset at the Ge/SiGe heterojunction. Comparison with *ab initio* calculations shows that quantitative agreement requires explicit inclusion of the confinement potential imposed by the SiGe barriers, which strongly affects the dispersion, ordering, and mixing of the hole states. Our results provide a direct experimental picture of the hole subband structure in Ge/SiGe quantum wells, establishing a basis for predictive design of group-IV quantum and electronic devices.

[1] Della Valle, E., et al. (2026). “Direct observation of strain and confinement shaping the hole subbands of Ge quantum wells”. <https://doi.org/10.48550/arXiv.2603.18753>.