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Strain Superlattice: A Combination of Strain Induced Self-Assembly and Strain Engineered Band Structure[1]

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Semiconductor nanomembrane affords a novel 2D platform for nanoscience and nanotechnology, especially for strain engineering of nanoelectronics. Strain is well known for band engineering to improve the performance of Si devices. The evidence that the band gap of Si changes significantly with strain suggests that by alternating regions of strained and unstrained Si one creates a single-element hetero-strain-junction electronic superlattice (SL), with the carrier confinement defined by strain rather than by the chemical differences in conventional SLs. Using first-principles calculations, we map out the electronic phase diagram of a 1D pure-silicon strain SL. It exhibits a high level of phase tunability, e.g., tuning from type I to type II. Our theory rationalizes a recent observation of a strain SL in a Si nanowire and provides general guidance for the fabrication of single-element strain SLs. The low-dimensional nanoscale strain SLs extend the concept of SL to a single element that exists in different structural states. It can be made in 1D nanowires or 2D nanomembranes by nanoscale self-assembly or by nanopatterning. It expands the application of strain engineering to new territories, by combining strain induced self-assembly with strain engineered band structure.

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