Spontaneous Relaxation through Graphene Suggests an Alternative Strain Relaxation Mechanism in Heteroepitaxy

Sang-Hoon Bae

Mechanical Engineering, Research Laboratory of Electronics, and Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, MA

While conventional epitaxy produces high-quality epitaxial layers, the limited set of commercially available wafers restricts the number of material choice that can be grown through epitaxy. To extend the set of epi-materials, heteroepitaxy has been widely used although the epi-materials have severe lattice mismatch from wafers. The problem of heteroepitaxy of the lattice mismatched systems is that introducing dislocations is unavoidable because of the strain energy built up in epitaxial layers exceeds the threshold energy value to create dislocation. As the dislocations significantly reduce the materials' properties, people have put intensive effort into finding a new way to resolve this issue.

Here, we introduce a new strain relaxation approach which can efficiently engineer the lattice with minimizing dislocation formation. Remote epitaxy allows single-crystalline growths on graphene-coated substrates as atomic potential field guides atomic registry through graphene while weakening binding energy of epilayer to the substrate. We discovered that this weakened interface offers a new pathway for strain relaxation during epitaxy in the lattice mismatched systems. While conventional heteroepitaxy relaxes accumulated strain energy through involving misfit dislocations, heteroepitaxy on graphene-coated substrates spontaneously relaxes its strain minimizing dislocation density. Thus, at the same thickness and misfit strain, the epilayer grown on graphene-coated substrates shows full relaxation with substantially reduced dislocations while that by conventional heteroepitaxy exhibits slight relaxation with full of dislocations. It means that full of strain relaxation at much lower thickness is available through this approach. We strongly believe that our strategy allows broadening range of available semiconductors through epitaxy, which could lead high performance electronic and photonics.