



PRODUCTION OF ARTIFICIAL SiGe QUANTUM DOT CRYSTALS

Task

Quantum dots (QD) are highly interesting objects with unique electronic and optical properties. The production of densely packed and well-ordered quantum-dot crystals makes it possible to create a new type of a solid body with an energy structure that does not exist in nature.

Method

Various process steps are necessary for the production of quantum-dot crystals: the basis is a silicon wafer, which is coated with a photoresist and structured by means of EUV interference or electron beam lithography over a large area. Subsequently, the nanoscaled hole pattern is transferred from the photoresist into the underlying substrate by means of reactive ion etching. The resulting depressions in the silicon determine the horizontal position of the quantum dots. Then the Ge quantum dots and the Si intermediate layers are grown onto the pre-patterned wafer by means of molecular beam epitaxy. The difference in crystal lattice constants of Si and Ge produces strain at the interface, thus enabling the growth of quantum dots. The vertical order of the quantum dots is produced by repeated, alternating growth of Si and Ge layers and by a vertical strain in the Si intermediate layer, caused by the shape of the Ge quantum dots. Thus, an artificial crystal is formed from ordered quantum dots in three dimensions with a grating period determined by lithography.

Results

In collaboration with Forschungszentrum Jülich, Fraunhofer ILT has produced artificial SiGe quantum-dot crystals in a hexagonal arrangement with a lateral lattice period between 200 nm and 40 nm. They have also been characterized by μ -photoluminescence spectroscopy.

Applications

The artificial quantum dot crystals or the directed self-assembly of quantum dots, based on the SiGe investigated here or a related III-V material system, makes a variety of applications possible, e. g. improving the efficiency of solar cells, producing lasers in the wavelength range of optical data communication or IR photodetectors.

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3 Hexagonally ordered Ge quantum dots.

4 Section of an artificial quantum dot crystal.