Directed Self-Assembly of Germanium Quantum Dots with E-Beam and EUV Interference Lithography

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Recent progress in nanotechnology and a constant increase in requirements on nanostructured devices in terms of integration density and energy efficiency are rapidly pushing feature sizes towards sub-10 nm dimensions. Interference lithography with extreme ultraviolet (EUV-IL) radiation is one of the most promising techniques to achieve this resolution on a large scale [1]. Thanks to the short wavelength (typically 13.5 nm) structuring with EUV light on a scale of a few tens of nanometers is not limited by diffraction. In contrast to high energy techniques, proximity and charging effects are negligible due to the very strong interaction of EUV radiation with matter leading to short (<100 nm) absorption distances. In contrast, e-beam lithography (EBL) enables fast changes in the pattern arrangement and allows the fabrication of non-periodic structures and is therefore also favorable for research applications.

Combining top-down lithography and bottom-up self-assembly one can fabricate two dimensional quantum dot arrays [2]. These dense and well-ordered arrays of QDs allow the realization of a novel type of solid matter with energy band distributions not existing in nature [3]. Such arrays can not only open up new possibilities for applications, but will also allow us to study fundamental questions of quantum tunneling in zero-dimensional systems, photon-electron-phonon interactions and electron transport phenomena [4].

In this study, the realization of ordered Ge quantum dots (QDs) on a Si substrate by means of EUV-IL or EBL and molecular beam epitaxy (MBE) is investigated (Fig. 1). A stand-alone laboratory EUV-IL system or EBL setup is utilized to fabricate a prepattern in photoresist with hexagonal arranged dots. The resulting structures are transferred from resist CSAR62 to the substrate by reactive ion etching. Subsequently, ultra-thin layers of silicon and germanium are deposited on top of the prepatterned substrate by MBE, enabling the growth of ordered arrays of QDs. The influence of the pitch, size and depth of the dot prepattern on the growth of the Ge QDs is examined and first results will be presented.

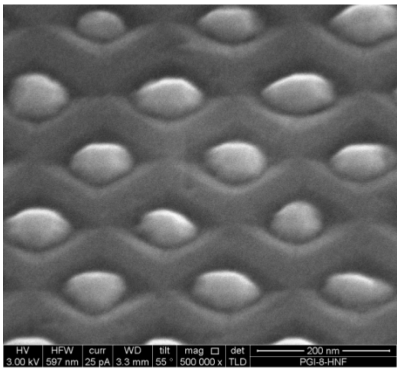

Figure 1:
The SEM image shows ordered Ge quantum dots on a Si (100) substrate with a pitch of 200 nm.

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