Narrow Photoluminescence Emission of Ge Islands Grown on Pit-Patterned Si(001) Substrates at Various Temperatures

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The advantages of Ge islands grown on pre-patterned Si(001) substrates as compared to randomly nucleated ones are the control over the nucleation sites as well as the island's homogeneous composition distribution. In this work we investigate the dependence of the island morphology and homogeneity on the substrate pattern period. By photoluminescence experiments the influence of the statistical size distribution on the optoelectronic properties of an island ensemble is monitored.

Ge islands were grown by molecular beam epitaxy at different temperatures (650 °C, 690 °C, 725 °C and 760 °C) on substrates pit-patterned by e-beam lithography with various pit periods p from 300 nm to 900 nm. Low Si capping temperature (300 °C) was used to preserve the island shape, size and Ge composition. Uncapped samples were grown for atomic force microscopy investigation.

We determine from the uncapped samples a clear correlation between the deposited amount of Ge per pattern unit cell with the size distribution and the morphological shapes of the islands. For the optimal amount, we observe significantly narrowed island photoluminescence emission peaks that are ascribed to the improvement of the Ge distribution homogeneity in the islands rather than to their shape homogeneity [1].

Beyond this optimal amount, dislocated superdomes are formed (see Fig.1 (c)). As a consequence, the island PL becomes almost completely quenched for these samples.

These findings emphasize the importance of accurate control over a parameter space including the deposition rate, the amount of deposited material, the pit period and the growth temperature of heteroepitaxial island growth on pre-defined positions.

References

[1] F. Hackl, M. Grydlik, M. Brehm, H. Groiss, F. Schäffler, T. Fromherz, and G. Bauer, Nanotechnology **22** (2011) 165302

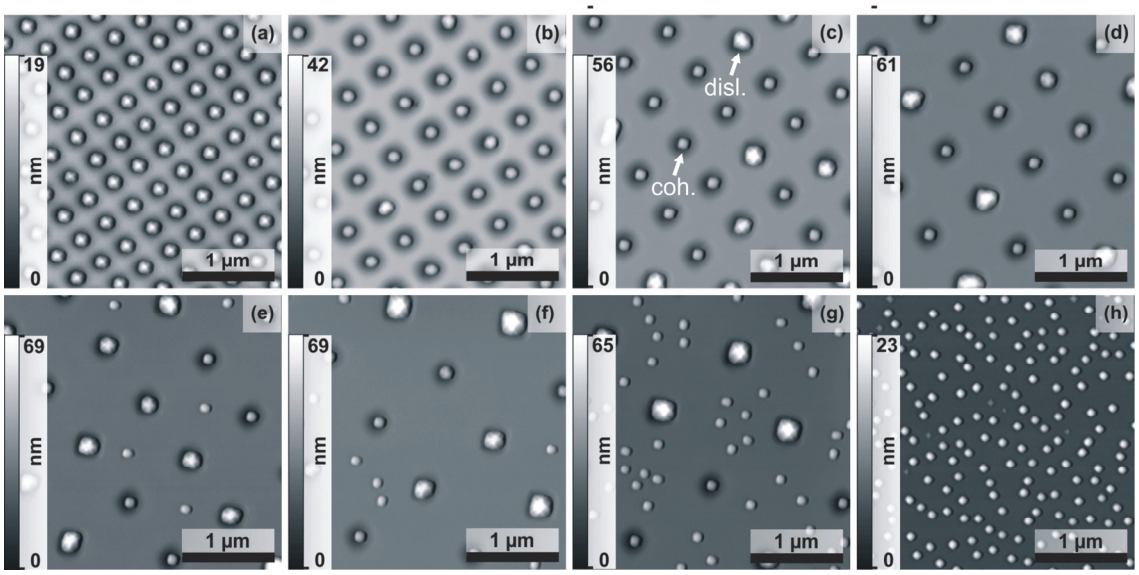

Fig. 1: AFM micrographs in height mode showing Ge islands grown at 690°C and at a rate of 0.05 Å/s on pit-patterned Si substrates with periods of 300 nm (a) to 900 nm (g). (h) islands grown on planar Si(001) substrate. In (c) dislocated super-domes, labeled “disl.” and coherent islands labeled “coh.” are indicated.