# Self-assembled strained GeSi nanoscale structures grown by MBE on Si(100)

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Nanostructures are particularly important objects in the nano - and optoelectronics. The basic materials investigations have focused on the modification of the material to improve its optical and electronic properties in order to realize the efficient light emitting or absorption [1].

The experiments have been carried out by a molecular beam epitaxy (MBE) installation “Katun”. Ex situ scanning tunnel microscopy (STM) with an ultrahigh vacuum instrument “Omicron-Riber” was used for the observation of the surface morphology.

The difference in surface energy for the strained planes of Ge(100) and Ge(105) is sufficiently small, hence the islands with {105} facet (hut-islands) are energetically more favorable in the low-temperature range as compared with the dome-islands which contain the facets with the surface energies significantly greater than the strained face of Ge(100). On the other hand, dome-islands are energetically more stable than the hut-islands due to the greater degree of the strain relaxation. At high temperatures, the value of the anisotropy becomes smaller due to the increase of the entropy and thereby the barrier lowers to the formation of dome-islands.

By forming of the thin Ge wetting layer and the subsequent annealing process we have obtained nanowires which were observed at the annealing temperature of 450°C. In the beginning the Ge film grows at the temperature of 500°C then the temperature of the substrate is reduced and this layer is annealed for 10 hours (figure 1). The Ge thickness corresponds to the wetting layer with the accumulated elastic strains. The surface morphology of the Ge layer have been demonstrated in figure 4. We have carried out our experiments in the wide range of annealing temperatures of 300-650°C. The same structures containing nanowires were obtained by Zhang et al. [2].

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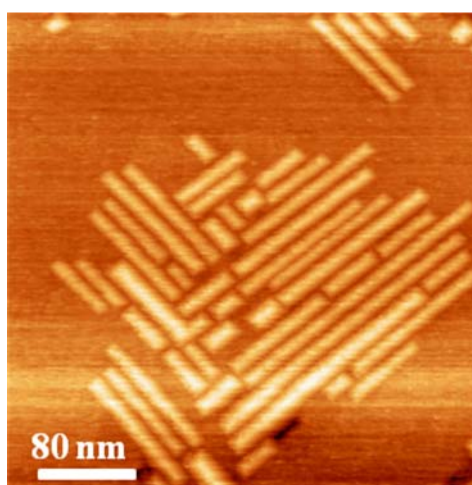


*Figure 1. STM image (400x400 nm) of Ge film after 10 h annealing at 450°C.*

**References:**

[1] A.I. Yakimov, A.I. Nikiforov, V.A. Timofeev et al., *Semicond. Sci. Technol.* **26**, 085018 (2011).
[2] J.J. Zhang, A. Rastelli, O.G. Schmidt et al., *Appl. Phys. Lett.*, **103**, 083109 (2013).