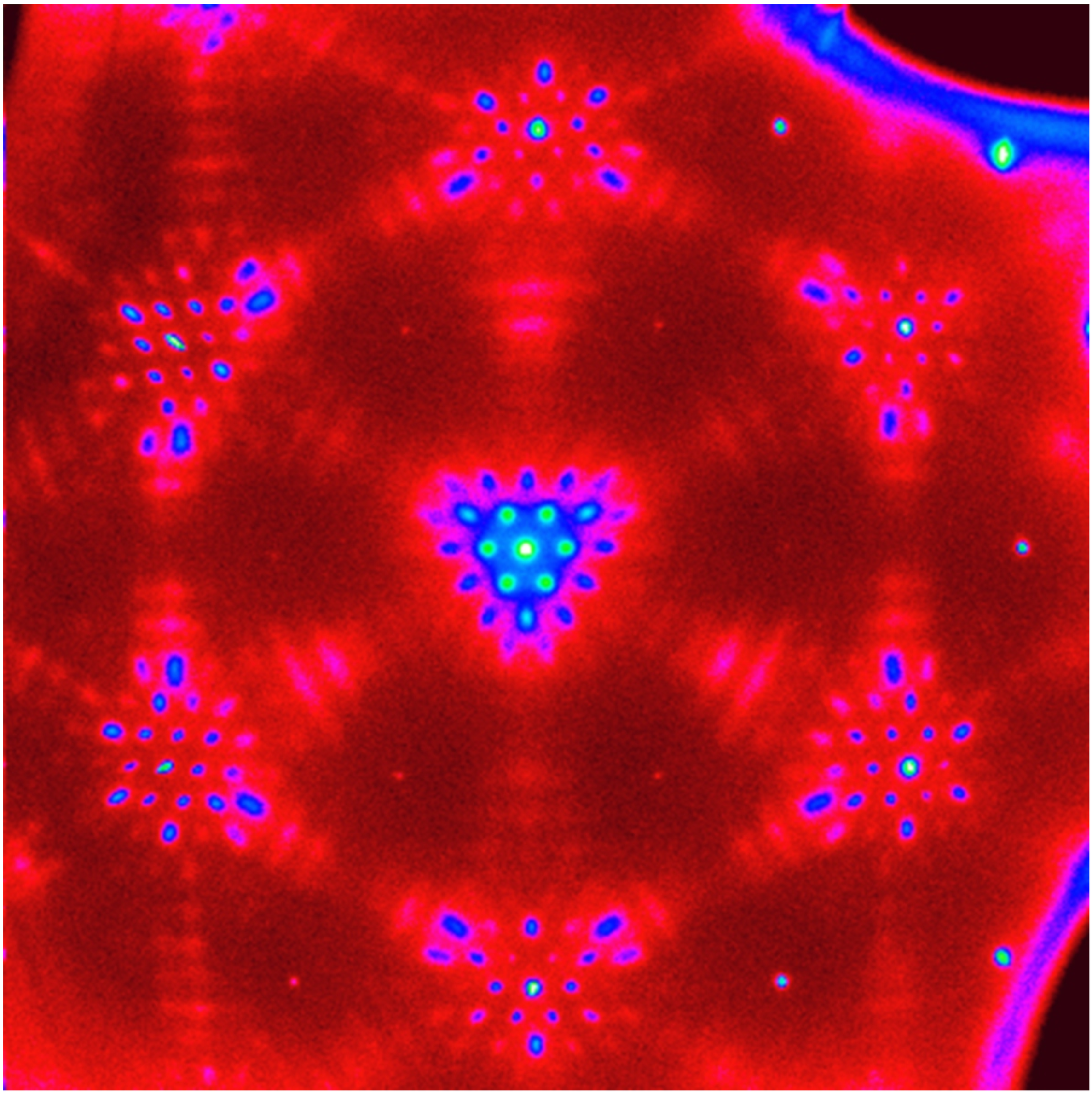


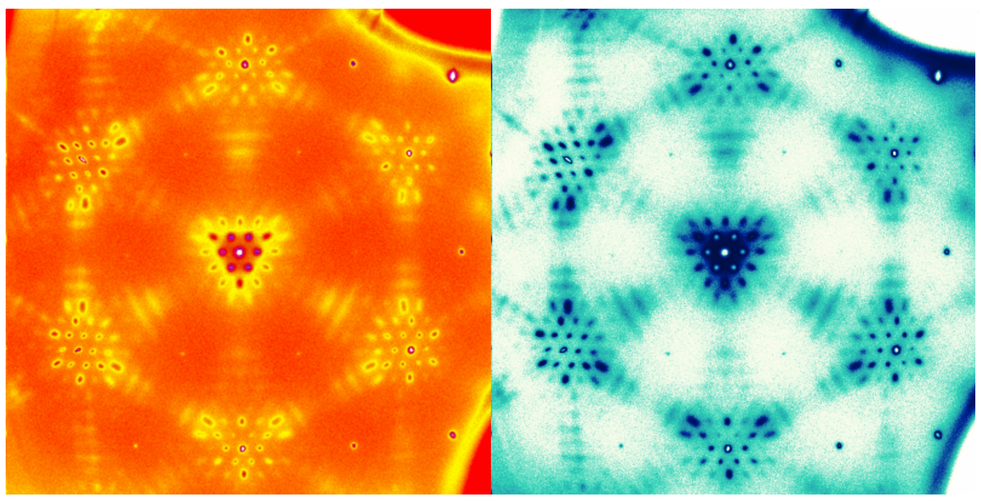
SPA-LEED pattern of

# 3 ML Ge deposited at 670°C on Si(111)

using Sb as surfactant.

"Honeycomb-Pattern"

## Cover picture of Omicron Newsletter III/01





TECHNIQUE

**Self-organisation of Ge nanostructures on Si(111)**
**A SPA-LEED and STM Study**

R.Hild, M. Kammler, I. Dumkow, M. Horn von Hoegen*

Self-organisation during epitaxial deposition is one of the most promising tools for the fabrication of 2-dim. ordered arrays of nanostructures on surfaces with dimensions much smaller than those obtainable by optical or electron lithography.

Almost ideal conditions are present in hetero systems with significant lattice mismatch. With the strain relief as driving force, structures evolve with a typical size of the inverse lattice mismatch $a_s/\Delta a$. For the Ge on Si(111) heterosystem with $\Delta a = 4.2\%$ lattice mismatch, two different types of 2-dim. ordered structures have been found in the case of surfactant mediated epitaxy [1]. During the pseudomorphic stage of growth the wetting layer shows a complex, honeycomb-like reconstruction [2]. (Fig.3)

The high resolution SPA-LEED pattern (Cover and Fig. 1)) allows the determination of a (6√3x6√3) reconstruction with a mean size of the unit cell of 3.5 x 3.5 nm. The width of the superstructure spots increases linearly with the distance to the integral order spot. This behaviour reflects a new type of 2-dim. disorder which has not been previously observed. The nature of the disorder can be identified in a corresponding STM image which was obtained from the same sample in a combined STM and SPA-LEED apparatus. The long range order of the superstructure can be described by 2-dim. correlated disorder, induced by local defects in the superstructure which elastically deform the entire array of unit cells.

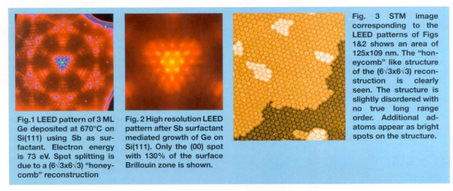


Fig.1 LEED pattern of 3 ML Ge deposited at 670°C on Si(111) using Sb as surfactant. Electron energy is 73 eV. Spot splitting is due to a (6√3x6√3) "honeycomb" reconstruction

Fig. 2 High resolution LEED pattern after Sb surfactant mediated growth of Ge on Si(111). Only the (00) spot with 130% of the surface Brillouin zone is shown.

Fig. 3 STM image corresponding to the LEED patterns of Figs 1&2 shows an area of 120x109 nm. The "honeycomb" like structure of the (6√3x6√3) reconstruction is clearly seen. The structure is slightly disordered with no true long range order. Additional adatoms appear as bright spots on the structure.

**SPA-LEED and STM - an Ideal Combination**

SPA-LEED delivers information in the reciprocal lattice space, while the STM delivers a corresponding real space image. This combination allows a truly comprehensive view of the sample.

The strength of one technique is the weakness of the other: SPA-LEED allows highly accurate measurement of the lattice constant in the lateral and vertical directions, averaged over a huge area, whereas STM allows the study of local (defect) structures. The STM probes only the topmost layer, while SPA-LEED allows the direct comparison of lattice constants of adsorbate and substrate.

The new conical geometry makes the SPA-LEED ideal for *in-situ* study of growth processes e.g. the changes in lattice constants and surface morphology. In addition, it is insensitive to thermal drifts, allowing measurements to be made during the cooling down phase after evaporation at elevated temperatures. Also, shadowing effects during evaporation such as those due to the STM tip are unknown.

[1] M. Horn von Hoegen, Appl. Phys. A 59, 503 (1994
[2] B. Voigtländer, A. Zinner, Surf. Sci. Lett. 351 L233 (1996)
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