In-situ GISAXS and GID investigations of the growth of Ge-islands on Si(001)

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Grazing incidence samll angle scattering (GISAXS) and diffraction (GID) measurements have been performed during the deposition of Ge on Si(001). The experimental setup allowed for a combined measurement in diffraction and small angle scattering geometry within only a few minutes. The monlayerwise deposition could thus be followed on an atomistic scale (evolution of the surface reconstruction and strain relaxation) as well as on the mesoscale (surface roughening during island nucleation, island morphology and faceting). Under GID conditions, the 2x1 surface reconstruction was monitored and in-plane reciprocal space maps were recorded in the vicinity of the Si(220) and Si(400) reflections were recorded. GISAXS images were registered with a 2D CCD detector.

The nucleation of islands can be monitored by the lattice relaxation that is visible in the vicinity of the Bragg peaks. The appearance of the (220) diffraction signal from nucleated islands as a function of the Ge deposit is shown in Fig. 1(a). It can be seen, that up to 3 deposited MLs, the diffraction signal ressembles to the one of a clean Si-surface indicating pseudomorphic strain in a 2D layer of Ge on Si. The change of the relaxation behaviour between 4 and 5 ML deposited can be atttributed to a change of the island morphology. For a deposit of up to 4 ML, the GISAXS pattern shows no change. The islands that nucleate at 4 ML are thus very flat objects. At 5 ML, first streaks from facets of type {113} appear. For increasing deposition, these streaks get narrower, indicating an increase in size of these facets (see Fig. 2 (b)). GISAXS images for a variety of azimuts were recorded. The most pronounced facets were found for {113} and {15 3 23} orientations as shown in Fig. 2 (c), confirming STM results published recently.

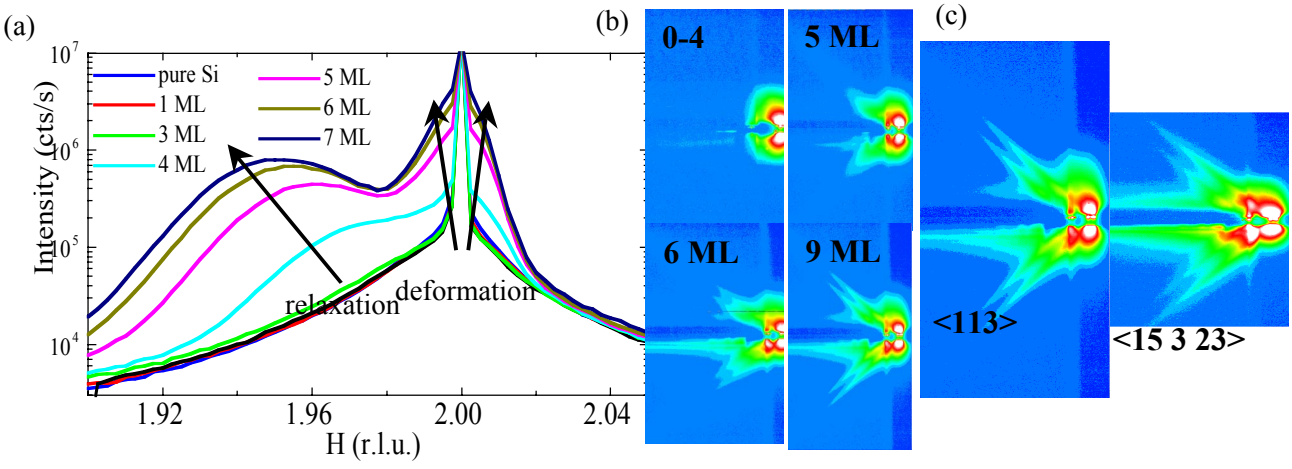

Fig. 2: (a): radial scan in the vicinity of the Si(220) reflection for different deposits of Ge. (b): GISAXS images in the <110> azimut showing the appearance of {113} facets. (c): The facet orientations {113} and {15 3 23} are dominating terminations of facetted domes .

Our experiments show, that about _ of the material that contributes to the wettinglayer diffuses into the island after the 2D-3D transition.