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Surface stress relief in Bi-mediated Ge growth on Si

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Interplay of surface stress and surface free energy determines the growth mode of heteroepitaxial layers. Therefore, surface morphology is sensitive to the presence of a third species on the surface, so-called surfactant. For instance, it is well known that SK growth mode of Ge on Si can be suppressed with the surfactant. In such surfactant-mediated epitaxy (SME), a flat Ge layer grows on Si while the surfactant floats up to the growth front and always covers the Ge surface.

Recently, Bi has attracted a lot of attention as a surfactant in Ge/Si heteroepitaxy due to its ability to suppress Ge-Si intermixing and provide a chemical contrast between Ge and Si in STM, allowing fabrication of self-organized Ge/Si nanostructures on the Si surface. In addition, low incorporation of Bi in the Ge layer allows to remove it from the surface after Bi-mediated growth.

In this work, we have focused on the stress relief during the initial stages of Bi adsorption on Si(111) 7x7 and Bi-mediated growth of Ge on Si(111). The stress behavior and surface morphology were observed simultaneously by using real-time measurements of the substrate curvature and RHEED. We find a difference in the surface stress between the Si(111) 7x7 surface and the relaxed Si(111) $\sqrt{3}$x$\sqrt{3}$ surface covered with one monolayer of Bi, and an evolution of the surface stress accompanied by RHEED intensity oscillation of the specularbeam during Bi-mediated Ge growth. When the Ge coverage approaches the critical value around 2 bilayers, the stress evolution shows a clear stress relaxation due to injected misfit dislocation into the Ge/Si interface and increasing surface roughness on the Ge surface. The observed stress evolution reveals the Bi-mediated growth with a variety of stress relief processes, which can drive changes in the heteroepitaxial growth mode.