Effect of adatom sink to atomic steps on the kinetics of Ge and Si two-dimensional island nucleation on Si(111)-(7×7) surface

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Recently, possible applications of Si–Ge–Sn heterostructures in photo- and microelectronics has attracted increased attention.[1,2] Solution of major challenges of this epitaxial system—composition uniformity, structural perfection—requires extending the comprehension of fundamental processes during Si–Ge–Sn growth.

We have studied by *in situ* ultrahigh vacuum reflection electron microscopy 2D island nucleation at the initial stages of Si and Ge growth on wide (up to 10 μm) Si(111)-(7×7) terraces far from atomic steps and near the steps. We have measured the concentration of 2D islands on the terrace (N_{2D}) and the width of depletion zone near steps where no island nucleates (W) as a function of deposition rate R and substrate temperature T in 500–750°C interval. Experimental depletion zone width W shows no dependence on crystallographic orientation of step. We fitted $W^{-2}(R,T)$ and $N_{2D}(R,T)$ dependences by $R^{\chi}\times\exp(E_{2D}/kT)$ approximation to determine effective activation energy of 2D island nucleation E_{2D} and scaling exponent χ.

We have found that scaling exponent χ of Si/Si(111) 2D nucleation rises from ≈0.57 far from steps to ≈0.92 near a step. This authenticates that the sink of adatoms to the steps increases critical nucleus size from i≈1 far from steps to i≈3 near a step while nucleation kinetics is limited by adatom attachment to step. For Ge/Si(111) 2D nucleation, we have obtained χ≈1.05 far from steps, but it *decreases* to χ≈0.7 near a step. This corresponds to the transition from the attachment-limited to the diffusion-limited nucleation kinetics near a step. We attribute these effects to high concentration of kinks at smooth steps that strongly facilitates the incorporation of adsorbed atoms into the crystal lattice, reduces their concentration near steps, and destabilizes 2D island nuclei.

The influence of Sn as a surfactant on the Si and Ge 2D nucleation on the Si(111)-(7×7) surface is scheduled to investigate in this work.

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