Ostwald ripening during GaAs(001) step-terraced surface morphology formation in equilibrium conditions

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Atomically flat crystal surfaces are needed for fundamental surface science, reproducible fabrication of nanoscale structures and device applications. A simple and cost-effective technique for GaAs surface smoothing by allowing surface migration at elevated temperatures was developed in Refs. [1,2]. In this technique the conditions close to equilibrium between the surface and Ga and As vapors, when neither growth, nor sublimation occurs, were provided by the presence of a saturated Ga-As melt. In the absence of an analytical theory, surface smoothing was described with direct Monte-Carlo simulation in the Kossel crystal model [3]. Both experiment and simulation show formation and growth of islands and pits of monatomic height on terraces during initial stages of surface smoothing. It is known that the growth of big islands at the expense of small ones is described by Ostwald ripening theory [4]. However, the influence of steps on a step-terraced surface can not be taken into account by the analytical theory and, therefore, was not investigated in detail in earlier studies.

In the present work the processes of island formation, growth and incorporation into atomic steps during thermal smoothing of vicinal GaAs(001) surface in equilibrium conditions are studied by comparing experimental results with Monte Carlo simulations. Fourier and autocorrelation analyses are explored to investigate spatial frequencies spectra of the surface relief and distribution of roughness size and shape. Combination of these methods allows us to trace mass transfer from islands into forming steps and to explain quantitatively the peculiarities of Ostwald ripening on terraces. It was found that despite the formation of vicinal steps, at the initial stage of smoothing the kinetics of island growth is well described by Ostwald ripening theory. At later stages of step-terraced morphology formation, a conventional increase in island mean size d is changed for the decrease in d due to evaporation of islands and their incorporation into steps. In other words, at the final stage the terraces play the role of macroscopically big "islands".

References

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