

Kinetics of Atomic Step Motion During Growth and Decay at Surfaces

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Atomic steps are common defects at surfaces that can play an important role in growth and many other physical phenomena. Step morphology will be affected, or even dictated, by the kinetic processes that mediate growth or its inverse, decay. In particular, step kinetic coefficient asymmetry is recognized to be an important and possibly common cause of morphological growth instabilities. However, the impact of this kinetic limitation on growth morphology may be hindered by other factors such as step permeability and the rate limiting step, which is characterized continuously between the diffusion limited (DL) and attachment/detachment limited (ADL) extremes by a quantity called the kinetic length. This strongly motivates experimental measurements of all of these quantities in real systems. Using low energy electron microscopy, we have measured step flow velocities in homoepitaxial growth on the Pt(111) surface (Fig. 1). The dependence of step velocity upon adjacent terrace width clearly shows evidence of asymmetric step attachment and step permeability. Step permeability, kinetic coefficient asymmetry and the kinetic length are evaluated quantitatively by comparing experimental data to a simultaneous solution of the diffusion equation on several adjacent terraces subject to general boundary conditions at intervening steps. Related quantities have also been investigated on the Si surface by examining island decay phenomena (Fig. 2). The power law time-dependence of the island area during decay reveals that the rate-limiting character of the decay kinetics is intermediate between the ADL and DL regimes. Mass conservation of decaying island stacks indicates that steps are impermeable. Island edge fluctuations are also evaluated to determine the step line tension and its dependence upon temperature. The step line tension is a crucial element in the Gibbs-Thomson relation which ultimately expresses the driving mechanism for decay.

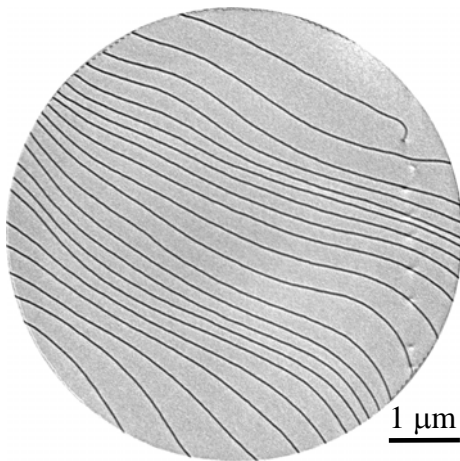


Fig. 1: Monatomic steps on the Pt(111) surface during homoepitaxial growth.

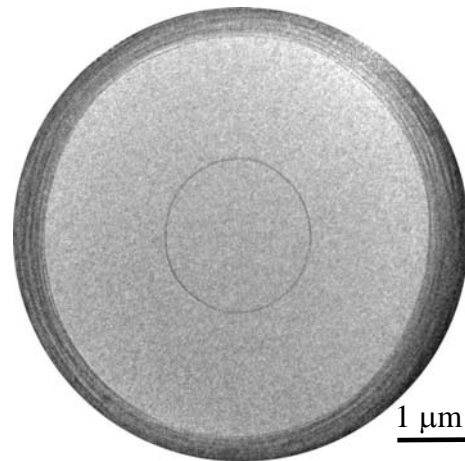


Fig. 2: Monatomic height island during decay on the Si(111) (1x1) surface.