Atomic-scale Study of Surface-based Nanostructures: Formation and Decay

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Surface-based nanostructures are at the forefront of exploratory work for next generation devices in the fields of electronic and optical industry, which rely on materials of ever increasing complexity and decreasing size. In most cases these nanostructures must be fabricated through either homoepitaxial or heteroepitaxial growth. The understanding of the kinetics involved in the formation and stability of these nanostructures on surface is of importance for the fast-growing area of nanotechnology. In this paper, I will show that, when a surfactant layer is used to mediate the growth[1], a counter-intuitive fractal-to-compact island shape transition can be induced by increasing deposition flux or decreasing growth temperature[2]. Specifically, I introduce a reaction limited aggregation (RLA) theory, where the physical process controlling the island shape transition is the shielding effect of adatoms stuck to stable islands on incoming adatoms[3,4]. Also discussed are the origin of a transition from triangular to hexagonal then to inverted triangular observed by experiments[5,6]. Based on our theory, for clean growth, only triangular islands of a fixed orientation are obtained within a wide range of growth temperatures. This novel picture is further corroborated by growth predictions in the presence of CO, whose preferential decoration of one type of the island edges reverses the intrinsic rate disparity for atom supply, thereby inverting the island orientation[7]. Furthermore, I will study the decay characteristics of islands on surface, as the stability of nanostructures after their creation is a critical issue for nanotechnology. Here I will show the fundamental mechanisms of atomic scale mass transport on surfaces with regard to the instability of surface nanostructures [8] and present a generic scaling law for decay characteristics on both isotropic and anisotropic surfaces. If time is allowed, I will also discuss a true upward adatom diffusion on metal fcc (110) surface [9,10].

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