Nanostructured surfaces

Temperature effects and adsorbate nano-sized structures formation at condensation from gaseous phase

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By studying the formation of nano-scale structures in the process of condensation from gaseous phase one supposes that the surface temperature is constant. Such an approach is a certain idealization, because it means that the surface temperature relaxes infinitely quickly to the bath temperature, and thus no local temperature change in the process of adsorption/desorption is impossible. From a physical point of view, when an atom from gaseous phase reaches the substrate (becomes adatom) and surface temperature locally increases. On the other hand, if the adatom desorbed from the surface, the temperature is reduced locally. Consequently, the competition of these processes, even at the mesoscopic level leads to local changes in surface temperature.

We study the dynamics of adsorbate nano-structures formation at condensation from gaseous phase by taking into account local changes in surface temperature at adsorption/desorption processes. It is shown that an increasing of the thermal conductivity of the surface results in the acceleration of pattern formation process. We have found that in the narrow time interval at initial stage of adsorbate structures formation the temperature field becomes redistributed: the adsorbate island become hotter than the substrate. An increase in the thermal conductivity leads to homogenization of the temperature field due to the large contribution of diffusion processes. We discussed evolution of mean size of adsorbate structures and show that on stages of adsorbate islands formation and their growth the mean size increases with time power-law form. It is shown that a taking into account the effects of local temperature changes leads to accelerated growth of adsorbate islands size compared to the normal law, characterized by the growth exponent 1/2. At the same time, an increase in the thermal conductivity of the surface results in increase of the growth exponent.