Nanoobjects microscopy

Obtaining and physical properties of mono- and multilayer silver and gold nanostructures

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It is well known that the growth mechanisms of thin metal films on various substrates are described by three basic types of growth: two-dimensional (2D) method or layer-by-layer growth (Frank–Van der Merve growth), layer-by-layer growth with further 3D islands growth (Stranski–Krastanov growth), 3D islands growth (Volmer–Weber growth) and model of "electronic growing". In thin films, electrons are quantized along the surface normal. Several of the electrons can be dissipated by the film-substrate interface. Consequently, there occurs a dependence of electron energy variation on the thickness, which comprises an electrostatic potential owing to the occurrence of the electric double layer with scattered electrons at the interface and the electrons oscillation along the direction of normal to the surface. The balance between these two phenomena determines the thickness at which the total electron energy has a local minimum. Thus, the film tends to flatten out and acquires the atomically flat morphology.

The formation mechanisms of Ag- and Au-ordered structures on single-crystal silicon Si(111) and Si(110) surfaces were studied by high-resolution scanning tunneling microscopy. It was shown that different patterns of self-assembled nanostructures with very precise and regular geometric shapes can be produced by controlling process parameters of thermal metal spraying on the substrate. The surfaces of nanorelief at each stage of deposition were invastigated, and the main stages of morphological transformation were fixed. Self-ordered hexagonal pyramid-shaped nanostructures were formed at thermal deposition of gold on the Si(111), whereas only monolayer hexagonal formation could be observed on the plane Si(110). Gold monolayer flake nanostructures were obtained under certain technological parameters. Atomically smooth Ag film cannot be obtained on the Si(111) surface by means of thermal deposition with room temperature sample. The formation of 2D clusters takes place; heating of these clusters at several hundred degrees Celsius leads to their transformation into atomically smooth covering. The weak interaction between Ag multilayer coating and substrate was established that allows to clear crystal surface from metal with reproduction of the reconstructed Si(111) 7×7 surface by slight heating. The offered method can be used for single-crystal surface protection from destruction.