ATOMIC FORCE AND TUNNEL MICROSCOPY OF ALUMINUM NANOISLANDS

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Abstract
Scanning atomic force microscopy (AFM) and scanning tunneling microscopy (TM) were proven to be extremely useful experimental techniques for characterization of thin films on metal or semiconductor substrate. The technique allows obtaining the films' valuable characteristics on interatomic distance spatial resolution level. The goal of this research is to study aluminum island films deposited on silica by atomic force microscopy and scanning tunneling microscopy techniques. Aluminum and alumina film's properties are especially interesting because the aluminum together with copper, gold and aluminum-copper alloys is an essential part of most modern electronic devices.

Aluminumislandsfilmsonsilicasubstratewerethermallydepositedinvacuum. The equipment is directly installed in the vacuum chamber which allowed controlling of the aluminum temperature, deposition speed and substrate temperature. The deposition time interval was a few seconds, and the pressure in the vacuum chamber reached 10^{-5}torr during the deposition process. A microscope INTEGRA NT-MDT, allowed measurements conducting in atomic force microscopy and tunneling microscopy regimes was used for precise surface topology study. Spatial resolution was determined by cantilever tip curvature and reached 40 nm in lateral plane. Scanning tunneling microscopy spatial resolution reached up to 1 nanometer.

Aluminum nanoislands film surface topography obtained by atomic force microscopy semicontact measurements are presented in Fig. 1 (The film was obtained by thermal deposition during 20 seconds). The size of islands varies distinctly from tens to a few hundred nanometers and this data points out a complicated island nanoscaled topology.

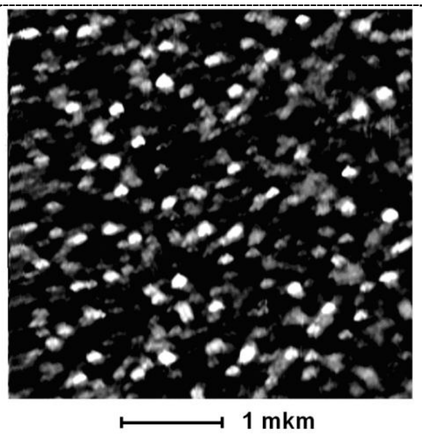

Fig. 1.AFM scan of surface of aluminum islands films on silica substrate.

In order to study the islands' structure more carefully we applied scanning tunneling microscopy technique. Typical scan results with space resolution of 1 nanometer are presented in Fig. 2.

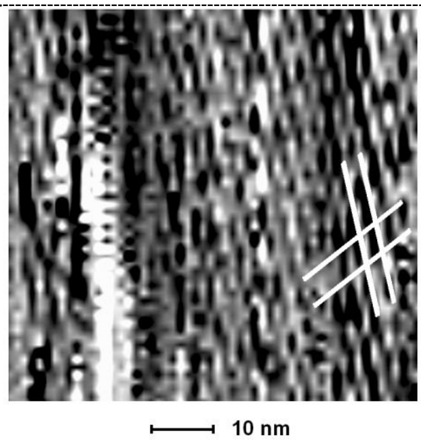

Fig. 2. Scanning tunneling microscopy scan of surface of the aluminum island on silica substrate. Spatial resolution is 1 nm.

The dark background on the picture, which has lower electric conductivity, comparing with neighboring regions, is originated from silica substrate. Secondly, the distinct rhomboidal gray structure (additionally marked by four white straight lines) with the height above the substrate roughness seems to be formed by alumina thin layers. The porous aluminum monoatomic layers exist just near the substrate surface and its' rhomboidal shape is influenced by silica face centered cubic lattice. Finally, the film structure in the places with higher thickness has nonrhomboidally
Despite of relative experimental complicatedness scanning tunneling microscopy techniques demonstrated a high effectiveness for aluminum nanoislands characterization. The presented results describe properties of an interface layer in the islands near the substrate surface. The layer has an ordered structure which was influenced by the substrate crystal lattice symmetry. Given results can be used for design of nanoscaled integration level chips.