Growth of hexagonal gold nanostructures during self-assembling on Ge(001) surface

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Nano sized gold has become an important material in various fields of science and technology such as nanoelectronics, catalysis, nanophotonics and medicine, where control over the size and crystallography of the structures is desired to tailor the functionality. The hexagonal closed packed (hcp) structure of gold is a very unusual form only recently chemically synthesized by Huang et al. [1] in form of graphene-supported thin sheets and nanowires of a few nm in thickness [2] and theoretically studied by Wang et al. [3]. The understanding of electrical as well as physical properties of the system is of great importance and strongly linked to their atomic structure.
In the presentation, we will report on studies concerning post-annealing induced nanostructures formation after room temperature deposition of thin film of Au on Ge(001) in UHV. Deposition of 6 ML of Au by MBE resulted in the formation of a continuous Au overlayer as checked by RHEED to be crystalline. Just after deposition, the samples were post-annealed in UHV to temperatures ranging from 473 K to 773 K with different cooling rates. The self-organized structures, in form of Au nanoislands, were characterized by HR-SEM and HR-STEM methods as well as conductive-AFM and Kelvin Probe Force Microscopy.
It has been found that there exists preferential island orientation along crystallographic direction of the substrate surface as provided by diffraction methods (EBSD). For an annealing temperature close to the eutectic temperature of Au/Ge system (640 K), change in size and shape of the Au nanoislands is observed as well as the apparition of the hexagonal phase of gold, indicating eutectic melting of the system. A (011) orientation of the Au islands with respect to the Ge surface was discovered, independently of the annealing temperature. TEM measurements of Au/Ge(001) sample cross sections revealed that the nanoislands created upon annealing at $T<640$ K are on top of the Ge(001) surface, while for $T>640$ K part of the island is buried beneath the substrate surface, which confirms the eutectic AuGe melting. The chemical composition of the Au/Ge interface was uncovered using quantitative atomically resolved HAADF-STEM and indicate the absence of alloying. The crystallographic structure of the Au islands and the presence of hexagonal gold as well as the Au/Ge interface were studied by quantitative atomically resolved HAADF-STEM and their structure was determined.

References

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