Zusammenfassung der Dissertation zum Thema:

PRODUCTION, DEPOSITION AND CHARACTERIZATION OF METAL NANOCLUSTERS USING A GAS AGGREGATION SOURCE

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Thin films play a very important role in the present day technology and its applications in optics and electronics is one of the most exploding field of researches in the present world. Consequently the development of thin film deposition techniques with controlled, reproducible and well defined properties plays an increasingly important role in technological applications. The impact of cluster beams produce much stronger effects on surface than ion beams with the same total energy, this is because of the much higher energy density and stopping power for the cluster beam. So this powerful technique can be used for the production of thin films. Low energy cluster beam deposition leads to thin films while energetic cluster ion deposition give strongly adhering films of high quality.

Simply clusters are aggregates of atoms or molecules, generally intermediate in size between individual atoms and aggregates large enough to be called bulk matter. Clusters are of fundamental interest: due to their intrinsic properties, because of their central position between molecular and condensed matter science. Interest in clusters also involves the evolution of geometric and electronic structures of clusters (as well as chemical and physical properties) with cluster size. The properties of clusters critically depend on its size, this size dependence may enable cluster-based material to be produced with noval optical, magnetic, or electronic properties. So thin films of metal nanoclusters deposited on a substrate is a very promising field for technological interest.

Transition-metal clusters have received much scientific and technological interest because of the distinction of complexity in both geometrical structure and magnetism. The localized and unfilled d shell usually result in spin multiplets and low-lying energy states that bring many useful physical and chemical properties of transition-metal clusters, making them highly promising in nanotechnological applications.

Ti is used as the key metal of our studies in cluster growth mechanisms, later on the cluster surface interaction processes are studied by using Ag. Fabrication of titanium oxide thin films has attracted considerable attention in recent years due to their unique electro-optical properties. These films exhibit a large potential in various fields such as electrochromic devices, air deodorisation, protective anti-reflection coating, solar cells, gas sensors and practical use appears feasible in the near future. Ag clusters draws

interest due to their unique applications in electronics devices also glass embedded with Ag nanoclusters has been used to record interference pattern of laser pulses

Titanium clusters of nanometer sizes are produced by magnetron sputtering with subsequent aggregation in an argon gas flow. The produced Ti clusters are directed and deposited on a silicon substrate. Deposited films are analyzed by x-ray photoelectron spectroscopy in order to obtain the chemical composition and by atomic force microscopy and x-ray reflection methods to obtain information about the film structure. We consider from a general point of view, conversion of a supersaturated vapour of metal atoms located in a buffer gas into metal clusters. Experiments were carried out at different temperatures of the walls of the magnetron chamber. The size and the flux of clusters from the magnetron chamber are obtained by the analysis of the substrate surface with deposited clusters. It is found that the cluster parameters strongly depend on the temperature of walls of the magnetron chamber. Molecules of titanium may be nuclei of condensation and accelerate the nucleation process.

A theoretical analysis based on experimental results is presented. It allows us to describe various stages of cluster evolution from their formation up to the deposition on the substrate and provides estimations for parameters of the processes involving clusters. Our estimate shows that the process of atom attachment to clusters is restricted to a rather narrow region near the cathode, where free metal atoms are present. Approximately one percent of free metal atoms are converted into clusters while the major part of free atoms returns to the cathode. The formed clusters flows out of the magnetron chamber along with the buffer gas flow. The surface coverage analysis of Ti clusters shows that the growth in to third dimension starts even before the first layer is finished. Ti clusters are found to be deposited as titanium oxide.

Silver clusters are produced in the same way. Clusters are size selected using a quadrupole mass filter (3-8 nm) or by varying the aggregation tube length (9-20 nm) of the nanocluster source. Mass selected clusters by quadrupole mass filter are deposited on a biased Si(100) substrate at different substrate bias voltages. We observed a pronounced flattening of clusters on the surface due to the increased impact energy by substrate bias. The whole list of processes that is possible in case of energetic cluster impact on surface are described. The behaviour of lattice parameters for size selected clusters, obtained by varying aggregation tube length is investigated. All measured lattice constants exhibits a tensile strain, it was found that the lattice constants increases with increasing cluster size up to a critical size of 12 nm and then decreases. The melting temperature of deposited clusters was found to be size-dependent and significantly lower than for bulk material, in agreement with theoretical considerations.

Comparatively thicker films of Silver nanoclusters deposited on Si substrates are studied using scanning electron microscopy attached with energy dispersive x-ray analysis (SEM/EDAX). The film deposition is performed at medium energy regime and deposition time is varied to get an idea about the evolution mechanism of such a film supported by Si-substrate. The morphology, composition and structures are investigated by SEM/EDAX and x-ray diffraction (XRD) and observed the Volmer-Weber and Stranski-Krastanov kind of growth in this case.