Nanomanipulation of Metallic Clusters on Insulating Substrates

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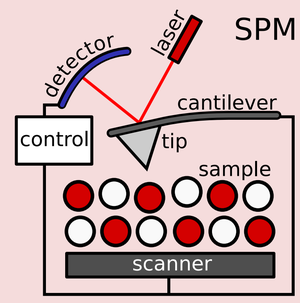
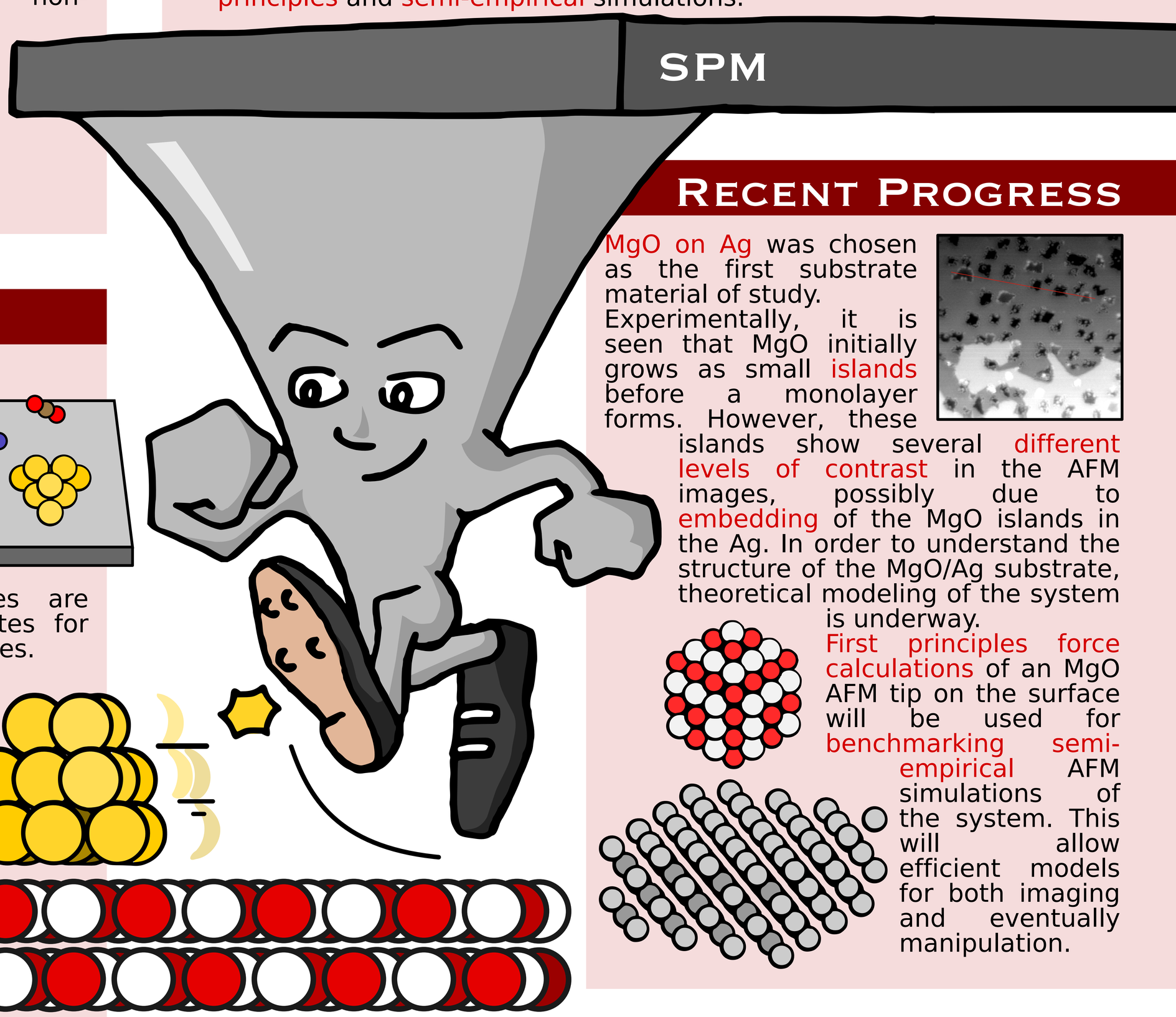
Introduction

Nanoclusters are a central system in nano-scale research. The properties of the clusters can be controlled by the number of atoms they contain and this has been recently coupled with the ability to modify the nanoclusters' physical properties via adsorption to a surface. The aim of the NOMCIS project is to apply scanning probe microscopy (SPM) manipulation, especially non-contact atomic force microscopy (AFM), to study the mobility and dissipation of nanoclusters adsorbed on surfaces as a function of nanocluster size and charge, their environment, site and surface material.

Methodology

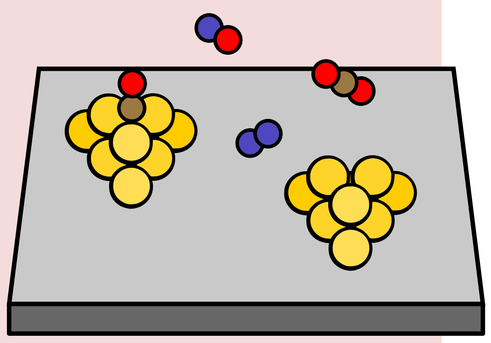
- The materials considered include Au, Ag, and Pd nanoclusters adsorbed on (001) surfaces of alkali halide and MgO crystals and thin films.
- Experiments: Size-selected clusters, deposited on a substrate, are imaged using SPM (measuring height, work function etc.) and manipulated by the imaging tip.
- Calculations: Interpretation of experimental SPM images and design of the experiments requires theoretical modeling of the systems. This is done via both first principles and semi-empirical simulations.





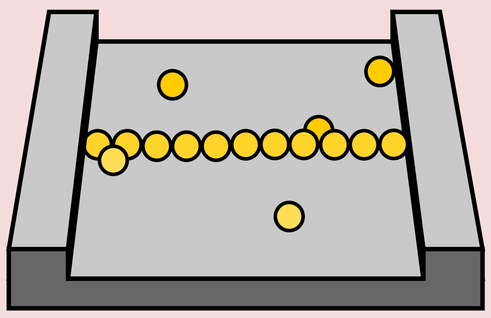
Applications

- Tuning the properties of clusters as a function of, e.g., size is an important investigative tool.



- Metallic clusters on oxides are reactive: important candidates for catalysts in industrial processes.
- As the adsorption sites of the clusters affect their properties, direct control over the positions of the clusters is important.

- Clusters are prototype systems for studying nanostructures. E.g., nanowires could be constructed to study nanoscale electron transport.



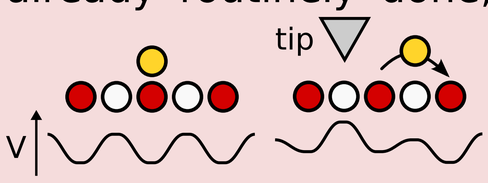
Recent Progress

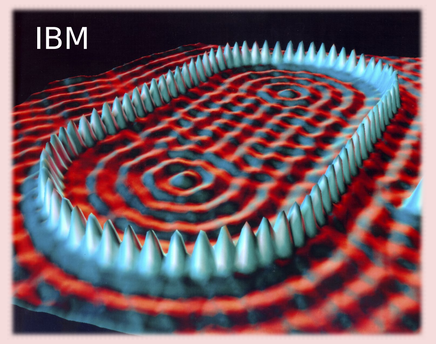
MgO on Ag was chosen as the first substrate material of study. Experimentally, it is seen that MgO initially grows as small islands before a monolayer forms. However, these islands show several different levels of contrast in the AFM images, possibly due to embedding of the MgO islands in the Ag. In order to understand the structure of the MgO/Ag substrate, theoretical modeling of the system is underway.

First principles force calculations of an MgO AFM tip on the surface will be used for benchmarking semi-empirical AFM simulations of the system. This will allow efficient models for both imaging and eventually manipulation.

Nanomanipulation

Direct mechanic manipulation of atoms by SPM tools is based on bringing the sharp SPM tip close to the surface, locally changing migration barriers to "kick" or "pull" atoms. Although SPM nanomanipulation is already routinely done, only few nanomanipulation studies on insulating substrates exist. Yet, insulating surfaces are essential in nanoelectronics.





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