ESF Short Visit Grant within NANOTRIBO: SCIENTIFIC REPORT

Applicant: Mª Teresa Cuberes, Engineering School of Almadén, University of Castilla-La Mancha, Spain.

Host: Enrico Gnecco, National Center of Competence in Research "Nanoscale Science", University of Basel, Switzerland.

Purpose of the visit: Scientific collaboration.

Description of the work carried out during the visit:

Following the plan detailed in our "proposed project work" (included in the grant application), during the short visit in the University of Basel we performed AFM manipulation experiments of Au nanoparticles deposited on HOPG (Highly Oriented Pyrolitic Graphite) substrates in air and in UHV environments.

For the air-AFM experiments, a drop of an 80 nm (in diameter) colloidal Au-particles solution (provided by K. Mougin) was poured on a freshly cleaved HOPG (0001) surface, and then gently rinsed out with He gas. In this way, we typically observed small aggregates of particles that could not be imaged in tapping mode without being disturbed (see Fig 1 (a) below). We tried different preparation procedures to modify the surface. Heating of the sample in air at 150ºC for 30 min led to the formation of rounded clusters (see Fig. 1 (b)); those of smaller diameter could be easily displaced by the AFM tip whereas the bigger ones remained fixed. Heating of the sample at 60ºC for 30 min without rinsing away the colloidal solution led to the formation of rougher aggregates (see Fig. 1 (c)). Nevertheless, the results could not be reproduced and the adequate control of the surface preparation procedure proved difficult to achieve.

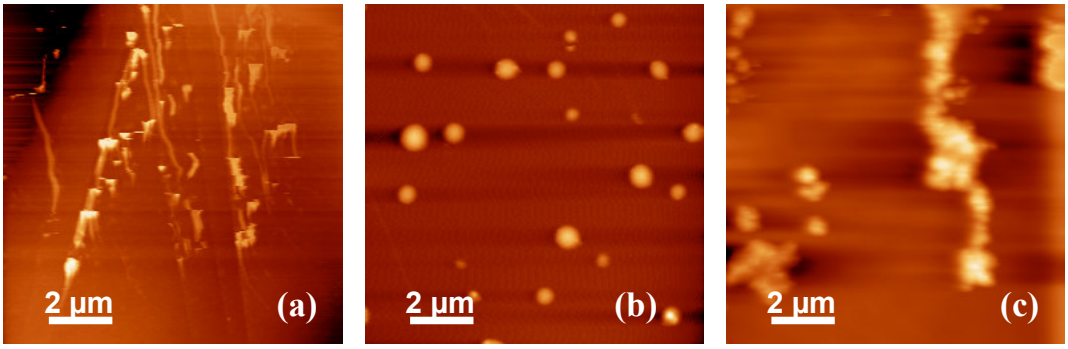

Fig. 1

The experiments in UHV were performed together with Dr. Thilo Glatzel. The HOPG sample was cleaved prior the introduction in the UHV chamber, and annealed in vacuum at 600ºC for 2 hours. Au was then evaporated in vacuum onto the clean surface. In contrast to the air experiments, the Au particles were much better resolved in the AFM images, and by successively imaging the same surface region, rotations and displacement of the particles could be appreciated (presumably induced by tip actuation) (see for instance the particles pointed by arrows in Fig 2; images in Fig. 2 range (250 x 250) nm and were recorded one after the other).

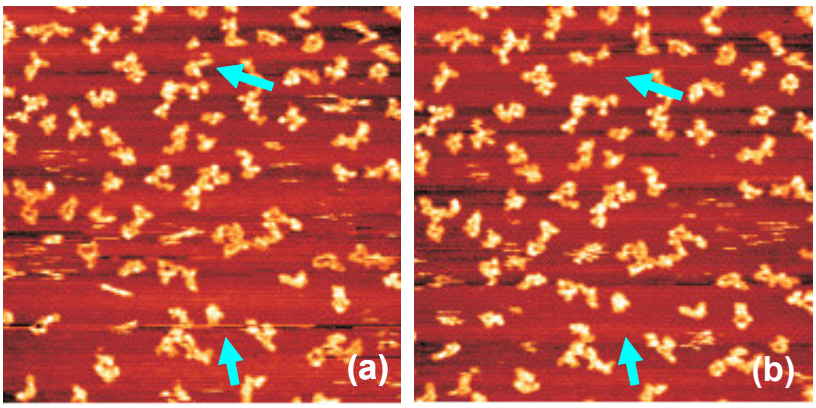

Fig. 2

Beside the performance of AFM experiments, the short stay allowed us to discuss Au manipulation experiments on Si substrates that had been previously done in Basel and in Madrid, and plan future work in collaboration.

Description of the main results obtained

The AFM experiments performed in Basel during my short visit demonstrate the possibility to manipulate Au particles on HOPG surfaces both in air and in UHV environments. The atomic-scale tribological properties of HOPG have been extensively studied, and hence it constitutes a model substrate for the understanding of 3-body (substrate-particle-tip) friction. Lamentably, a lack of reproducibility in the sample preparation methods for the air experiments hindered the achievement of decisive conclusions.

Future collaboration with host institution

We plan to continue our work in collaboration related to AFM manipulation of Au nanoparticles. In particular, we expect to perform:

(i) Additional experiments related to UHV-AFM manipulation of Au nanoparticles on HOPG substrates.
(ii) Additional experiments related to AFM manipulation of Au nanoparticles on Si substrates in controlled environments (at different humidities).

Moreover, we aim to focus our main efforts in the development of novel AFM-based methods that allow us to gain control in the manipulation procedure, such as the use of ultrasonic vibration to modify the tip-sample-particle frictional behaviour.

Projected publications/articles resulting or to result from our grant

The short visit in Basel has reinforced our scientific contact, and has allowed us to plan future research strategies in collaboration. Nevertheless, our work is still in its initial stage, and more experiments are needed to reach decisive conclusions. Reasonably, publications in collaboration related to the topic of AFM manipulation of Au nanoparticles will come out during the next year.