„Forces at the nanoscale: From superlubric nanoparticles to molecular manipulations."

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The atomic force microscope (AFM) is an indispensable tool for surface characterization in material science down to atomic scales. While most force microscopy applications are related to surface structure characterization, recent progress has been reported in the field of AFM-based surface manipulations. Minute forces can not only be detected by the cantilever-based sensors, but exerted in a controlled way. An example is the simultaneous manipulation and detection of lateral forces during nanoparticle sliding, relevant for our understanding of microscopic friction mechanisms. In particular the contact area dependence of friction for atomically defined interfaces was found to obey a sub-linear scaling [1], contradicting the widely accepted linear Amontons law. In the extremely sensitive non-contact AFM mode, controlled tip-induced motion of individual atoms and molecules is possible. In the case of the perylene derivative PTCDA on Ag, the force needed to push the molecule by one atomic lattice site was measured [2], which is directly linked surface diffusion energy barriers. Lately, we have refined the pick-up procedure of CO-molecules from metal surfaces. Those CO-functionalized AFM tips allow chemical bond imaging of organic molecules, and were for example used to follow each individual reaction step of the Ullmann coupling reaction of triphenylenes. This progress opens the path to study material properties at the nanoscale by controlled AFM manipulation techniques.

[1] D. Dietzel et al., Physical Review Letters 111 (2013) 235502.

[2] G. Langewisch et al., Physical Review Letters 110 (2013) 036101.