Molecular mechanisms of lubrication

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1. Introduction

Molecular mechanisms of lubrication have been studied by high-resolution atomic force microscopy (AFM). We will report on two different material systems, which exhibit fascinating lubrication properties at the nanometer scale. The structural quality of graphene layers attached to a steel surface as well as the preparation of Au(100) single-crystal electrodes by flame annealing provide us with surfaces of the quality familiar from Surface Science experiment in vacuum.

2. Graphene at the solid-liquid interface

Graphene is the two-dimensional building block of graphite, a well-known solid lubricant. Friction force microscopy on graphene allows for the observation of atomic stick-slip process processes, and thus for the analysis of molecular mechanisms underlying friction [1-3]. Here we will report how friction and the molecular structure of a liquid lubricant oil change at the steel interface due to the presence of graphene [4].

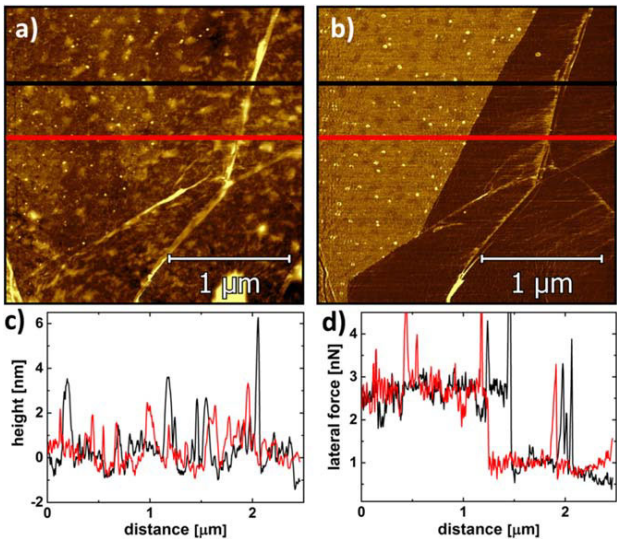

Fig. 1. Force microscopy images of a steel surface partially covered with a layer of graphene. a) and c) Topography and cross sections. b) and d) Friction force and cross section. The lower friction reveals the part of the surface which is covered with graphene (from Ref. [4]).

3. Ionic liquid as lubricant

Ionic liquids are promising materials for lubrication, given their viscosity, low vapor pressure, and electric conductivity. When confined to the nanometer-scale gaps, the structure of ionic liquids becomes ordered in molecular layers. Normal forces oscillate when closing the gap between the confining surfaces. We introduce magnetically actuated dynamic shear force microscopy as a method to measure the shear viscosity of confined ionic liquids. The confined liquids exhibit quasi solid properties at shear rates of the order of 10^{-6} s^{-1}.

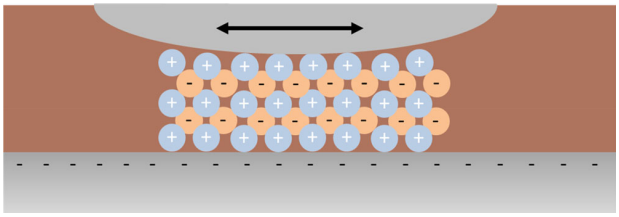

Fig. 1. Schematic depiction of dynamic shear force microscopy on an ionic liquid which is confined between AFM tip and surface. This molecular rheology experiment indicates an almost crystalline structure of the liquid in confinement.

References

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