

Molecular Rheology and plastic dissipation of a few atoms size Gold NanoMeniscus

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Despite extensive documentation of plastic deformation processes in micro-sized samples, there is up to now no clear understanding of the mechanisms governing plastic flow in nanoscale systems. Rheology allows the study of the flow and deformation of materials, but has been so far restricted to macroscopic soft matter samples such as liquids, foams, or emulsions.

Here, we extend this technique to the molecular scale, by performing rheological measurements on gold meniscus of only a few atoms width. Submitting the meniscus to increasing sub-nanometric deformations, we characterize the gold meniscus viscoelastic properties, and uncover a dramatic transition from a purely elastic regime to a non-linear plastic like regime, up to the complete shear-induced melting of the meniscus, leading to the appearance of attractive capillary-like effects.

Our measurements allow us to measure the critical yield force governing the onset of plastic flow in the junction, as a function of size. In those molecular systems, plasticity seems to be limited by the sliding of atomic planes under shear, as expected for dislocation starved systems.