Few Atoms Non-Linear Rheology of a Molecular Gold Meniscus

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Rheology allows to study the non-linear flow response of soft materials, but has been so far restricted to macroscopic samples such as suspensions, foams, or emulsions. Here, we extend this technique to the molecular scale, by performing rheological measurements on metallic gold nanojunctions of only a few atoms width, using a quartz-tuning fork based Atomic Force Microscope. Submitting the junction to increasing sub-nanometric deformations, we characterize the junction 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. We analyse and rationalize our results in the framework of a harmonically-driven Frenkel-Kontorova model. Our measurements give unprecedented insight into the deformation mechanisms at play in atomic sized metallic systems.