

The lateral force apparatus (LFA)

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The Lateral Force Apparatus (LFA)

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Introduction

Quantitative single asperity experiments can be used to study friction [1, 2] and wear [3]. For such measurements it is important to be able to independently measure friction and normal force [4], as well as indentation [1–4], in steady sliding over a large velocity range [2].

Description

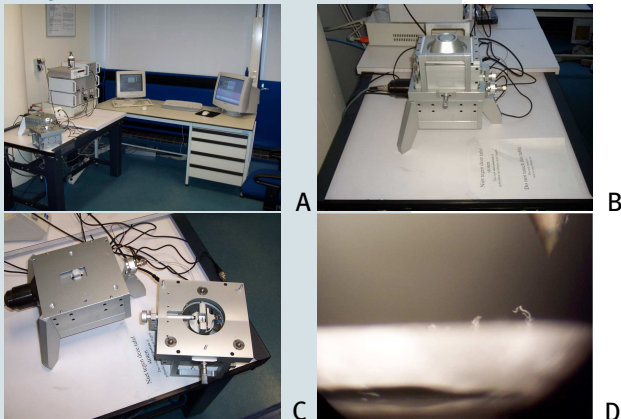


Figure 1 Pictures of the LFA. A: Overview. B: Measurement part, closed. C: Measurement part, open. D: Tip and above sample. To the left of the tip the damage of three wear experiments can be seen.

The LFA is designed to achieve sliding velocities between 10 nm/s and 1 mm/s, and measure position with an accuracy of 1 nm. No explicit limitations to force range and tip size are defined; if the cantilever and tip can be produced, any force corresponding to a 20 μm deflection of the cantilever can be measured. Vertical motion (indentation) can be measured through a piezo.

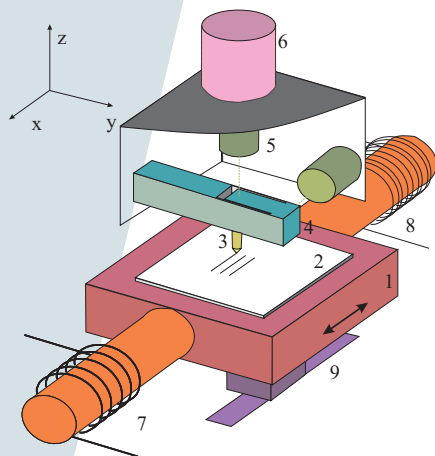


Figure 2 Schematic representation of the LFA. 1 sample stage, 2 sample, 3 tip, 4 cantilever, 5 focus error detectors, 6 piezo, 7 driving coil, 8 measurement coil, 9 digital linear scale.

Performance

The lowest achievable velocity was defined as the velocity that could be distinguished from stand still within a 2σ statistical error.

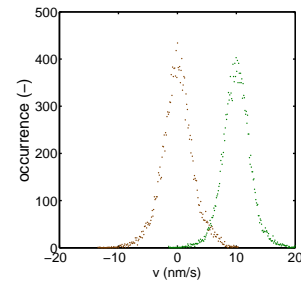


Figure 3 Histogram of velocities measured at rest and at a set stage velocity, v , of 10 nm/s. The two curves intersect at 2σ deviation from the average value, indicating a significant distinction between rest and 10 nm/s can be made.

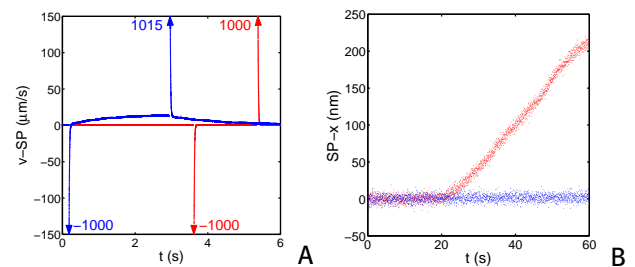


Figure 4 Deviation from the set point at instantaneous acceleration/deceleration, **with** and **without** position control. Velocity control is used in either case. A: Deviation from velocity set point at $v = 1 \text{ mm/s}$. B: Deviation from position set point for $v = 10 \text{ nm/s}$.

It was found that below $v = 1.5 \mu\text{m/s}$ position control was essential to accurately control the motion, at higher velocities position control caused an error in the actual velocity. This could lead to a slow motion when programming standstill after a large deceleration. At high velocity differences, a choice has to be made between accurate velocity or accurate position.

Conclusions

The LFA can be used to accurately quantify single-asperity tribology over a wide range of velocities, forces and length scales.

References:

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