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

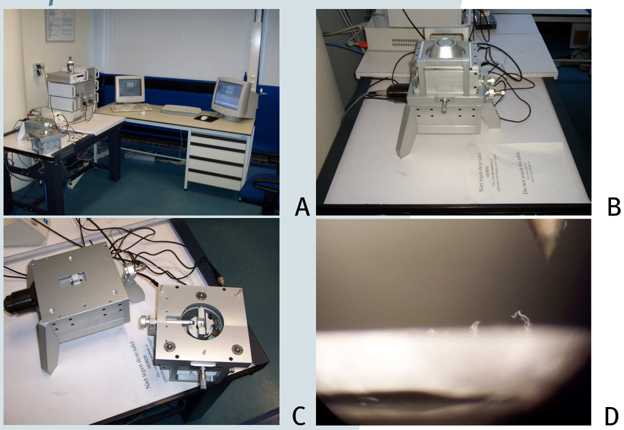

Figure 1 *Pictures of the LFA. A: Overview. B: Measurement part, closed. C: Measurement part, open. D: Tip and above sample. To the left of the tip the damage of three wear experiments can be seen.*

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.

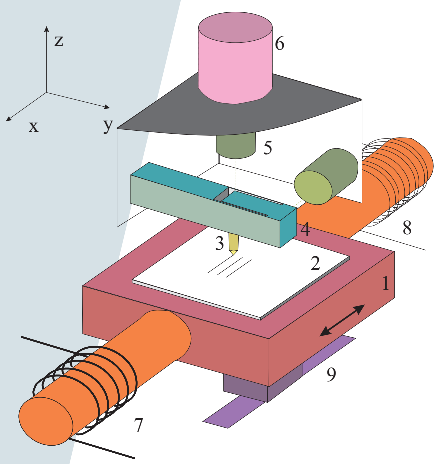

Figure 2 *Schematic representation of the LFA. 1 sample stage, 2 sample, 3 tip, 4 cantilever, 5 focus error detectors, 6 piezo, 7 driving coil, 8 measurement coil, 9 digital linear scale.*

Performance

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

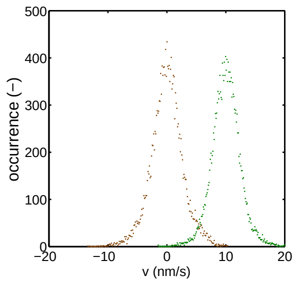

Figure 3 *Histogram of velocities measured at rest and at a set stage velocity, v, of 10 nm/s. The two curves intersect at 2σ deviation from the average value, indicating a significant distinction between rest and 10 nm/s can be made.*

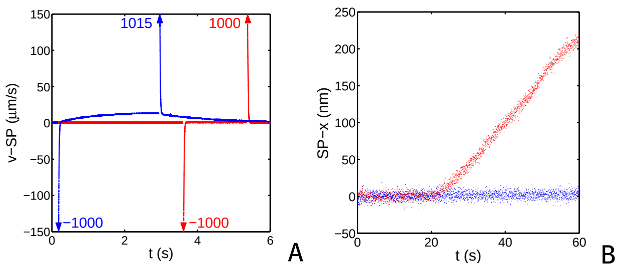

Figure 4 *Deviation from the set point at instantaneous acceleration/deceleration, with and without position control. Velocity control is used in either case. A: Deviation from velocity set point at $v = 1$ mm/s. B: Deviation from position set point for $v = 10$ nm/s.*

It was found that below $v = 1.5\mu$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:

[1] R. P. Schaake, W. P. Vellinga and H. E. H. Meijer: *Proceedings of the 30th Leeds-Lyon Symposium on tribology* etc

[2] R. P. Schaake, W. P. Vellinga, J. M. J. den Toonder and H. E. H. Meijer: submitted to *Tribol. Lett.*

[3] R. P. Schaake, J. M. J. den Toonder, W. P. Vellinga and H. E. H. Meijer: submitted to *Macromol. Rapp. Comm.*

[4] W. P. Vellinga and C. P. Hendriks: *Tribol. Lett.* 9 (2000) 119–124

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