

PicoBalance: mass measurements by AFM

Hans Gunstheimer^{1,2}, Laura Gonzalez^{1,3}, Gabriel König¹, Gotthold Fläschner³, Patrick Frederix¹

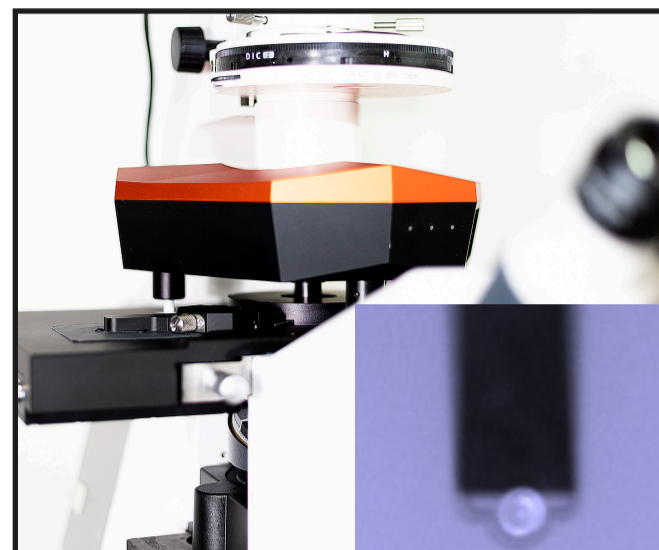
1: Nanosurf AG, Gräubernstrasse 12-14 4410 Liestal, Switzerland

2: TU Ilmenau, IPMS, Ehrenbergstr. 29, 98693 Ilmenau, Germany

3: Biophysics group, ETH Zurich, D-BSSE, Mattenstrasse 26, 4058 Basel, Switzerland

Introduction

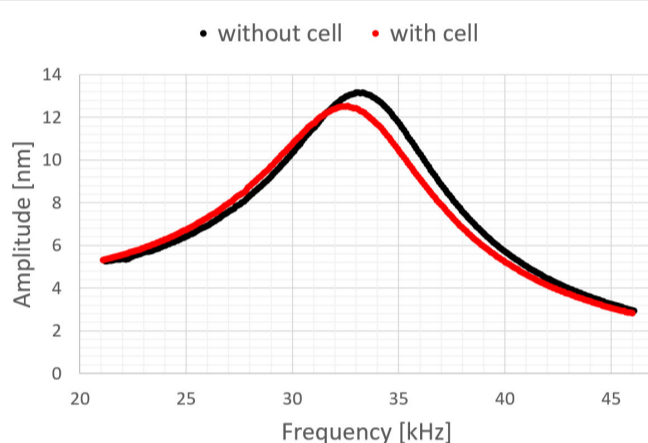
The development and regulation of biological cell mass can be related to many diseases ⁽¹⁾. For example, mass of healthy cells fluctuates and increases over time while virus-infected cells stop growing ⁽²⁾. Nanosurf in collaboration with ETH Zürich had developed the DriveAFM which makes it possible to determine the mass of single cells under physiological conditions or microparticles in air and liquid.



Working principle

The mass is obtained by attaching a sample to a cantilever beam and tracking the change of the cantilever's resonance frequency.

This method allows to study samples at the lower nanogram up to the picogram range.



Amplitude response of a fibroblast cell (1.7 ng)

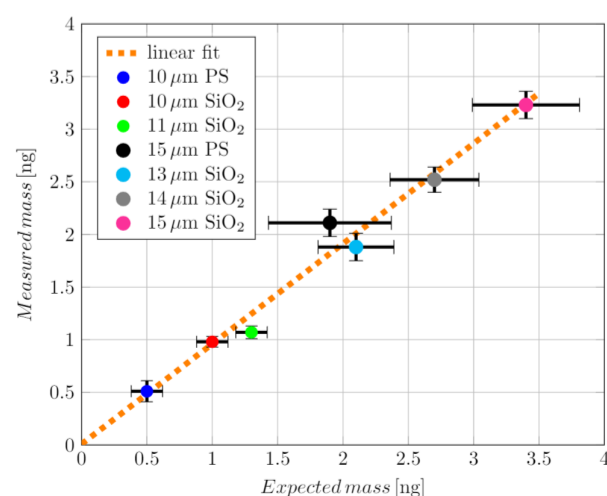
$$\Delta m = \frac{k}{4\pi^2} \left(\frac{1}{f_{0,w}^2} - \frac{1}{f_{0,w/o}^2} \right)$$

The sample is picked up by FluidFM Micropipettes or a coated cantilever, where the cantilever dimensions specify the mass sensitivity.

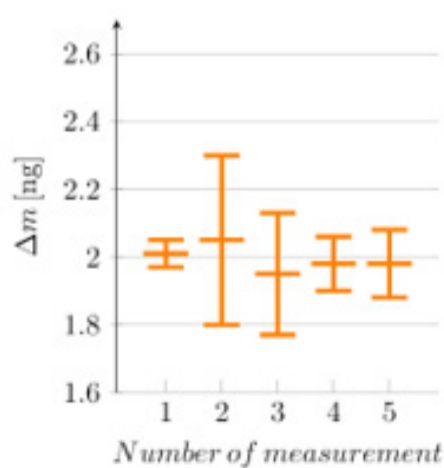
A phase-locked-loop facilitates long term measurements with 10 ms time resolution. The cantilever is actuated by photo-thermal excitation (CleanDrive).

Mass calibration

PS- and SiO₂- Microbeads were used as calibration weights. The measured mass with the PicoBalance showed a lower uncertainty than the expected mass calculated from bead specifications. The repeatability of the PicoBalance lies within a deviation of 0.08 ng.



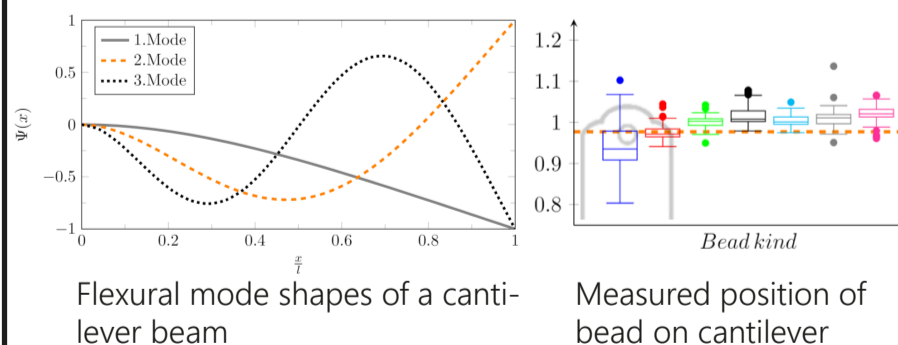
Linearity: every data point represents 25 measurements



Repeatability: same bead measured five times

Position detection

The value of the measured mass depends on the sample position at the cantilever. For the position detection an approach using higher flexural modes (3) was tested in liquid. The obtained position deviates in average 3 μm from the expected position.



References

- (1) Lloyd, A. C. Cell 154, 1194 (2013)
- (2) Martinez-Martin D. et al. D. Nature, 550, 500 (2017)
- (3) Dohn S. et al. Rev. Sci. Instr. 78, 103303 (2007)