

P7 – Optical Tweezers With Millikelvin Precision of Temperature-Controlled Objectives and Base-Pair Resolution

Mohammed Mahamdeh

Nanomechanics Group,
BIOTEC TU Dresden, Germany

In optical tweezers, thermal drift is detrimental for high-resolution measurements. In particular, absorption of the trapping laser light by the microscope objective that focuses the beam leads to heating of the objective and subsequent drift. This entails long equilibration times which may limit sensitive biophysical assays. Here, we introduce an objective temperature feedback system for minimizing thermal drift. We measured that the infrared laser heated the objective by 0.7K per watt of laser power and that the laser focus moved relative to the sample by ≈ 1 nm/mK due to thermal expansion of the objective. The feedback stabilized the temperature of the trapping objective with millikelvin precision. This enhanced the long-term temperature stability and significantly reduced the settling time of the instrument to about 100 s after a temperature disturbance while preserving single DNA base-pair resolution of surface-coupled assays. Minimizing systematic temperature changes of the objective and concurrent drift is of interest for other high-resolution microscopy techniques. Furthermore, temperature control is often a desirable parameter in biophysical experiments.

Optical tweezers with millikelvin precision of temperature-controlled objectives and base-pair resolution



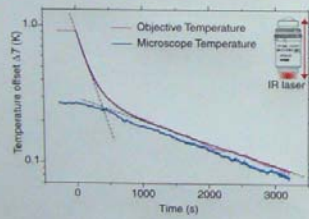
Mohammed Mahamdeh and Erik Schäffer
 Nanomechanics Group, Biotechnology Center, TU Dresden,
 Tatzberg 47-51, 01307 Dresden, Germany



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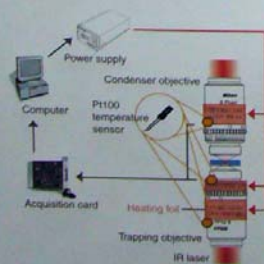
Motivation

Laser induced heating causes drift and long equilibration times



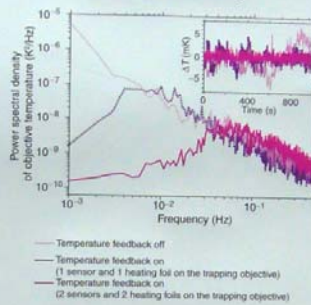
Solution

Temperature feedback system



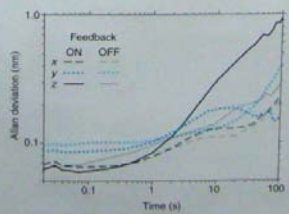
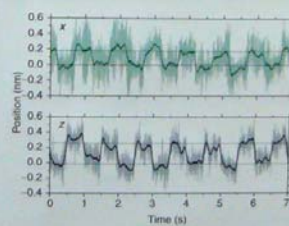
Results

1. Temperature feedback improves temperature stability

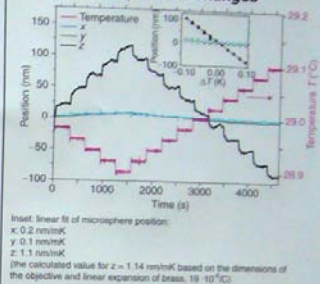


2. Single DNA base-pair resolution with temperature feedback

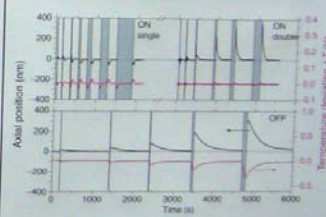
Lateral (1.8 Å) and axial (2.7 Å) steps of an immobilized microsphere (light color: raw data, dark color: 200 adjacent point averaging)



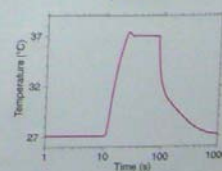
3. Trap movement correlated with temperature changes



4. Feedback restores equilibrium fast



5. Fast increase of objective temperature is possible



Conclusion

Laser heating of the objective can cause hundreds of nano-meters of movement due to thermal expansion and that relaxation times are long.

Stabilizing the objective with millikelvin precision reduces equilibration time and improves the throughput of high resolution experiments.

When using temperature feedback, it is possible to perform experiments under exactly the same temperature condition.

Reference:

M. Mahamdeh and E. Schäffer, "Optical tweezers with millikelvin precision of temperature-controlled objectives and base-pair resolution," *Opt. Express* 17, 17190-17199 (2009).

Acknowledgement:

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Contact and more information:

mohammed.mahamdeh@biotec.tu-dresden.de
<http://www.biotec.tu-dresden.de/schaeffer/nanomechanics/index.html>