SURFACE SCANNING
USING OPTICALLY TRAPPED PROBES

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Characterization of nanometer scaled surface structures is an important task in many scientific applications. Various surface scanning methods have already been established, e. g. the atomic force microscope (AFM). The photonic force microscope (PFM) utilizes an optically trapped bead as a probe to scan a surface. The displacements of the probe are detected in three dimensions and with nanometer accuracy by back focal plane interferometry. The interference pattern of unscattered light and the light scattered by the probe is recorded with a quadrant photo diode with sample rates up to one MHz. Phase disturbances caused by the structured surface are corrected for. Although the 200 nm probe is larger than the tip of an AFM cantilever, the stiffness of the optical trap can be tuned to values 1000 times softer than a typical AFM cantilever. Soft surfaces can be examined without destroying them.

The aim of this scanning probe technique is to image both the relief of a surface and its interaction potentials as well as local viscosities. Local diffusion coefficients on structured surfaces can be measured, which are encoded by the probe's fluctuations on the µs scale. Remarkably the thermal position fluctuations of the probe do not decrease the image resolution, but increase it (see Figure) and allow imaging of surface structures clearly beyond the classical resolution limit. In order to further improve image resolution and contrast, the influence of the nano-scaled probes is investigated as well as concepts for spatial filtering with the interferometric detection scheme.

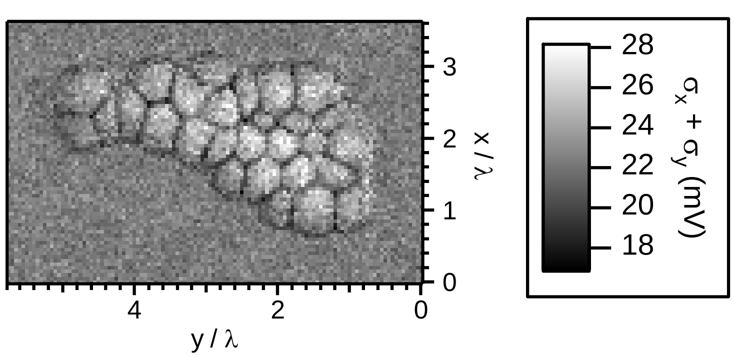

Figure: Agglomeration of silica particles with a size of ~ 400 nm imaged by fluctuation changes of an optically trapped probe (raw data); scaling the axes in $\lambda = \lambda_0/n$ = 800 nm shows that this method reveals structures much smaller than the used wavelength.

[1] E. L. Florin, A. Pralle, et al., JSB 119(2) (1997)
[2] C. Tischer, S. Altmann, et al., APL 79(23) (2001)
[3] P. Seitz, E. H. K. Stelzer, et al., AO 45(28) (2006)