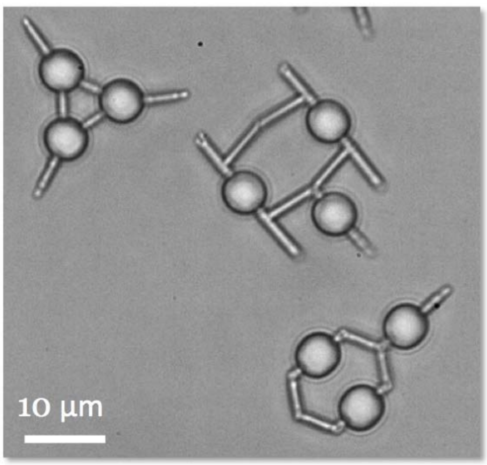
4π AFM using a Light Touch

Mervyn Miles[1]
D.J. Phillips[1], S. Olof, J. Grieve, D.M. Carberry, S. Simpson[1], S. Hanna[1], D.J. Engledew[1], G. Gibson[2], R. Bowman[2], M.J. Padgett[2]
Nanoscience & Quantum Information Centre[1] & School of Physics and Astronomy[2]
University of Bristol[1] & University of Glasgow[2]
U.K.

We have use optical tweezers to develop a new type of atomic force microscope (AFM). AFM offers unique characteristics amongst microscopy techniques including high-resolution 3D imaging in many environments including liquids, which are clearly essential for most biological studies. However, there are limitations, one of which is the requirement that the sample should be approximately planar. This is a consequence of the AFM cantilever and tip scanning in a plane, essentially in 2D. The tip only 'sees' the sample from above with the sides and bottom surfaces of the sample being inaccessible.

Using holographically generated traps, we have overcome this limitation by steering the tip of a nanorod in a three dimensional scan, with six degrees of freedom, such that it is possible to scan around a sample from any direction. The holographic optical traps allow not only positioning of the optical traps in x and y but also in z by changing the effective for focal length of the objective lens independently for each optical trap. We have used various probe types: including silica and cadium selenide nanorods, rod-like living diatoms, and two-photon polymerized 3D structures [1,2]. The force sensitivity is around 50 fN.

1. Phillips DB, et al., Nanotechnology 22 (2011) Art. No. 285503.
2. Olof SN et al., Nano Letters 12 (2012) 6018-6023.



Some examples of nanotools used as AFM probes. Two-photon polymerisation has bee used to generate a range of structures, the designs of which were informed by detailed simulations of the EM field and hydrodynamics.