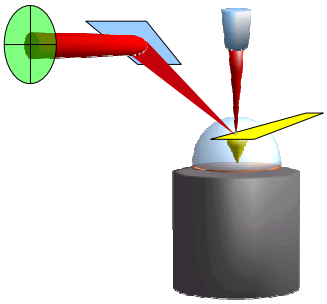
Imperial College London

UCL

Atomic force microscopy

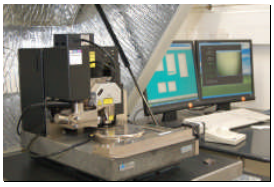
LCN LONDON CENTRE FOR NANOTECHNOLOGY

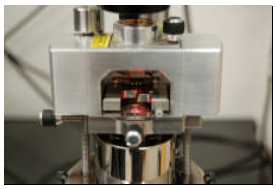
Description of the technique

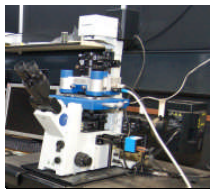


Atomic force microscopy (AFM) involves a sharp tip, mounted on a flexible lever ("cantilever") that is scanned over the sample surface as a miniature blind-man's stick. The force between the tip and the sample is typically detected via a laser beam deflected from the cantilever. The line-by-line surface contours can be merged to create a 3D image of the sample surface. AFM can be performed in air, liquid (as shown in the image on the left), or in ultra-high vacuum conditions.

This poster shows some **selected applications**, based on measurements carried out at the LCN



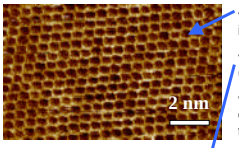




AFM user facilities at the LCN: Several of the atomic force microscopes at the LCN are accessible for all members of UCL and Imperial College, provided that they have followed one of our AFM trainings. Shown here are our Bruker-AXS (formerly Veeco) Dimension 3100 (left) and Multimode (centre), as well as one of our JPK Nanowizards (right).

Apart from the instrumentation, our key strength lies in the vast AFM expertise that is available in the LCN.

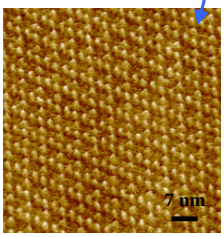
Biomolecules and biomolecular complexes

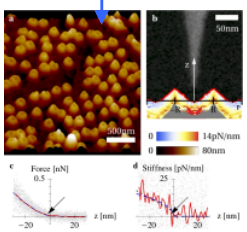


• Atomic-resolution imaging of surfaces in physiological buffer solutions – mica

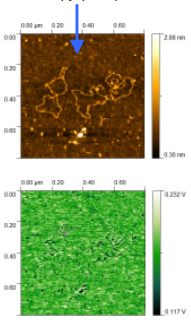
• 2D crystal of membrane proteins (bacteriorhodopsin), in buffer solution

• Imaging intact nuclear pore complexes and probing the stiffness of their central channel, in buffer solution



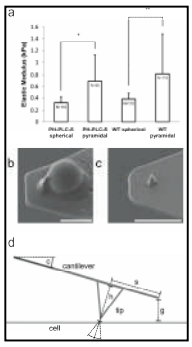


• DNA structure (top) and electrostatic surface potential (bottom) measured by Kelvin Probe Force Microscopy (in air)



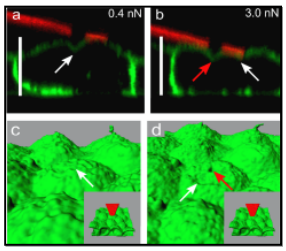
Probing elasticity of living cells

On a combined AFM/confocal-microscopy set-up, fluorescently marked cells can be imaged and probed to determine their viscoelastic properties



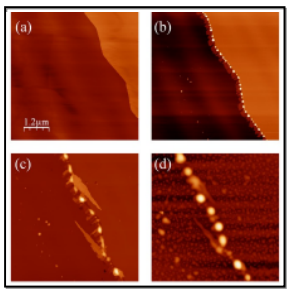
Measurement of the elastic modulus:

(a) The elastic modulus using pyramidal tips was found to be greater than values obtained using spherical tips. (b) SEM image of a spherical tipped cantilever (scale = 10 µm). (c) SEM image of a pyramidal tipped cantilever (scale = 5 µm). (d) geometric considerations of the clearance between cell and end of the cantilever.

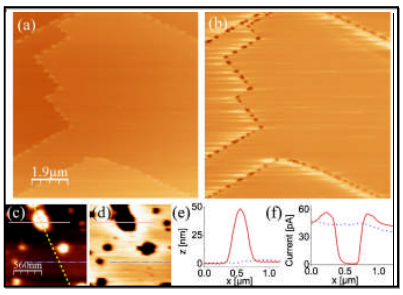


(a) At low applied force, indentation is due to the tip only. (b) Contact area is increased between flat part of the cantilever and cell surface. (c,d) 3-D iso-surface reconstructions of the cell surface

Organic semiconductors: structure & conductivity



Rubrene grows beads at step edges: a) 1 hour after cleaving, (b) 1 day after cleaving, (c) 7 days after cleaving, (d) 11 months after cleaving. The colour scale is 10, 13, 45 and 150 nm respectively



Rubrene surface structure and conductivity (2 months after cleaving): a) topography (contact mode – scale 100nm), (b) Current measured by Conductive-AFM, of the same area (scale 200pA). (c) and (d) show topography and a C-AFM map, respectively, near a step edge highlighted in (c). (e) and (f) show topography and conduction profiles, respectively, of the indicated paths in (c) and (d)

Publications

• Charras, G.T., Yarrow, J.C., Horton M.A., Mahadevan L. and Mitchison T.J. (2005). Non-Equilibration of Pressure in Blebbing Cells. *Nature*, **435**, 365-369.

• Charras, G. T., Williams, B. W., Sims S., and Horton, M. A. (2004). Estimating the sensitivity of Mechanosensitive channels to strain and tension. *Biophys. J.*, **87(4)**, 2870-2884.

• Credgington, D., Fenwick, O., Charas, A., Morgado, J., Suhling, K. And Cacialli, F. (2010). High-resolution scanning near-field lithography of conjugated polymers. *Adv. Func. Mater.* **20(17)**, 2842-2847.

• De Luca, G., Pisula, W., Credgington, D., Treossi, E., Fenwick, O., Lazzerini, G. M., Dabirian, R., Orgiu, E., Liscio, A., Palermo, V., Müllen, K., Cacialli, F. and Samori, P. (2011). Non-conventional processing and post-processing methods for the nanostructuring of conjugated materials for organic electronics. *Adv. Funct. Mater.*, **21**, 1279-1295.

• Fenwick, O., Bozec, L., Credgington, D., Hammiche, A., Lazzerini, G. M., Silberberg, Y. R., Cacialli, F. (2009). Thermochemical nanopatterning of organic semiconductors. *Nature Nanotech.* ***4****, 664-668.*

• Grüter, R. R., Khan, Z., Paxman, R., Ndieyira, J. W., Dueck, B., Bircher, B. A., Yang, J. L., Drechsler, U., Despont, M., McKendry, R. M. and Hoogenboom, B. W. (2010). Disentangling mechanical and mass effects on nanomechanical resonators. *Appl. Phys Lett.*, **96**, 023113.

• Harris, A. R. and Charras, G. T. (2011). Experimental validation of atomic force microscopy-based cell elasticity measurements. *Nanotech.*, In press.

• Khan, Z., Leung, C., Tahir, B.A. and Hoogenboom, B.W. (2010). Digitally tuneable, wide-band amplitude, phase and frequency detection for atomic-resolution scanning force microscopy. Rev. Sci. Instrum., **81**, 073704.

• Leung, C., Kinns, H., Hoogenboom, B. W., Howorka, S. and Mesquida, P. (2009). Imaging surface charges of individual biomolecules. *Nano Lett.*, **9(7)**, 2769-2773.

• Leung, C., Maradan, D., Kramer, A., Howorka, S., Mesquida, P. and Hoogenboom, B.W. (2010). Improved Kelvin probe force microscopy for imaging individual DNA molecules on insulating surfaces. *Appl. Phys. Lett.*, **97**, 203703.

• Thompson, R. J., Yadin, B., Grout, Z. J., Hudziak, S., Kloc, C. L., Mitrofanov, O. and Curson, N. (2011). Evolution of the surface morphology of rubrene under ambient conditions. *Appl. Phys. Lett.*, **98**, 053302.

LCN team

Nano-scale optical lithography on polymer surfaces

• Academics leading the work shown here: Franco Cacialli, Guillaume Charras, Neil Curson, Bart Hoogenboom

• AFM facility management: Richard Thorogate, Guillaume Charras and Bart Hoogenboom

• Collaborators: At present there are about 70 regular users of the LCN AFM facilities (mostly from UCL and Imperial College)

• Contact details: Richard Thorogate (r.thorogate@ucl.ac.uk, 020 7679 0569, x30569) and Bart Hoogenboom (b.hoogenboom@ucl.ac.uk, 0207679 0606, x30606)

• More information: http://www.london-nano.com/research-and-facilities/facilities/bloomsbury-site/afm-lab

• New users will be required to follow our AFM training: http://www.london-nano.com/research-and-facilities/facilities/afm-lab/afm-training (since 2008, we have trained >150 users on our microscopes)

Acknowledgements

EPSRC Engineering and Physical Sciences Research Council

BBSRC bioscience for the future

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