Journée thématique Fermat
FluidFM: principles and applications in life and material sciences

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FluidFM technology combines AFM with microchanneled AFM probes[1]. In this system, a micro-sized channel is integrated in an AFM cantilever and connected to a pressure controller system (pressure range from -800 to 1000 mbar), thus creating a continuous and closed fluidic conduit that can be filled with a solution, while the tool can be immersed in a liquid environment. An aperture of size ranging from 300 nm to 8 µm at the end of the cantilever allows liquids to be dispensed locally. Force feedback is then ensured by a standard AFM laser detection system that measures the deflection of the cantilever and thus the force applied to the sample[1].

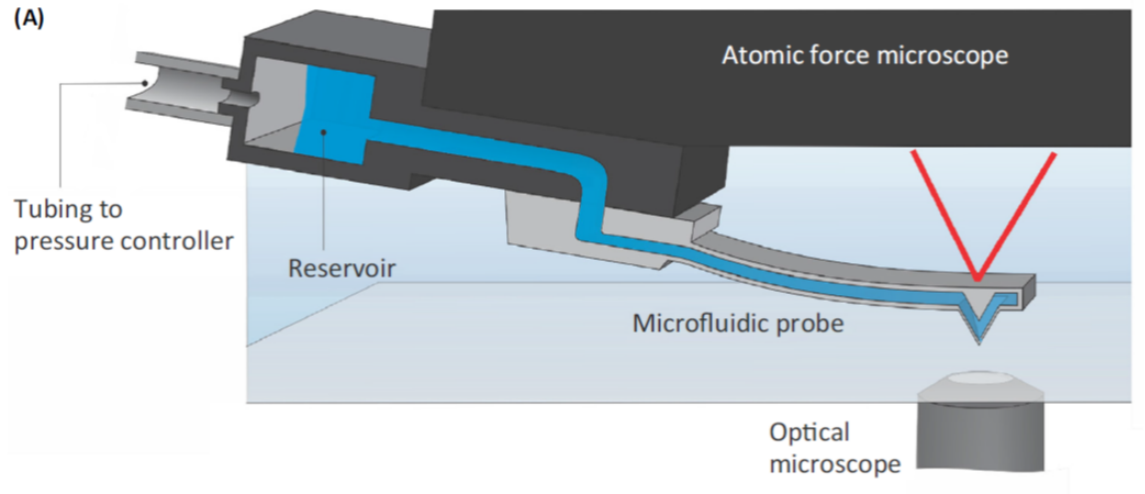

Figure 1. *Principle of FluidFM technology. Reprinted from* [1].

This technology, which is commercially available, has many applications both in life and material sciences. Here are some examples of such applications.

In material sciences

- Hydrogels fabrication: local dispense of molecules on surfaces to produce microstructured hydrogels for applications in biomedical surface modification and tissue engineering[13].
- Lithography in liquid: patterning of nanoparticles on surfaces thanks to the fluidic cantilever on surfaces. Generic method for the deposition of soluble nanoparticles in liquid[14].
- 3D-printing: cantilever used as a local source of metal ions in liquid. Voxel-by-voxel 3D-printing process of metals. Fabrication of array of pillars, hollow structures, helices…[15]

In life sciences

- Manipulation of single living cells: captured at the aperture of the cantilever by aspiration and released by overpressure at a different location[2]. Applications for cell patterning and cell isolation. Can be performed with different cell sizes, from bacteria[3] to yeast and mammalian cells[4].

- Quantification of adhesion forces: capture of cells at the aperture of the cantilever and measure of the interactions with different interfaces in force spectroscopy experiments. Applications for understanding adhesion mechanisms of living cells to different surfaces, or to other cells[5,6].
- Local delivery of liquid: local deposition of specific molecules at proximity of cells. For example, deposition of a neurotransmitter next to rat neurons and recording of the simulation pulses induced by the neurotransmitter[7]. Or deposition of virus on top of mammalian cells to understand the virus cell entry and infection[8].
- Force-controlled nano-injection and extraction: injection of controlled volumes of fluids directly within cells for applications for example in cell transfection[9]. Or extraction of fluids directly from cells to analyze cell's inner metabolites in specific conditions[10].
- Patch-clamping: the cantilever can be used a micropipette to patch-clamp cells and measure their electrophysiological properties[11].
- Nanopore microscopy: the FluidFM cantilever is used as a nanopore to sense secreted molecules and the activity of ion channels in arbitrary locations both inside and outside a cell[12].

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