Atomic Force Microscopy based techniques developed for high spatio-temporal resolution imaging and nanomechanical characterization of cells

T. Neumann, T. Müller, D. Stamov, H. Haschke, E. Hartmann, T. Jähnke

JPK Instruments AG, Colditzstr. 34-36, 12099 Berlin, Germany

Topography, roughness, adhesion and mechanical properties are relevant characteristics reflecting the cellular state in terms of morphogenesis, differentiation or cell division as well as cellular function. Atomic Force Microscopy (AFM) is a versatile tool suitable for measuring all of these characteristics with nanometer scale resolution under controlled environmental conditions. We have developed a multipurpose AFM device allowing comprehensive characterization of biological samples such as live cells or tissues. True optical integration allows the simultaneous use of advanced optical techniques such as DIC or confocal laser scanning microscopy.

With our unique "Quantitative Imaging" (QI™) mode several cell and tissue properties, such as the topography, stiffness and adhesiveness, can be obtained with one measurement. Even more complex data like Young´s modulus images, topography at different indentation forces in terms of tomography, or recognition events can also be obtained. A variety of biological samples have been investigated to demonstrate the capability and flexibility of QI™.

The JPK ULTRA Speed technique allows fast AFM imaging to follow dynamic processes on the cell surface. Morphological changes, like membrane budding events or cytoskeletal reorganization can be viewed with high spatiotemporal resolution.

A variety of accessories are available, e.g. for environmental control or providing additional measurement modes, such as micromanipulation or adhesion measurements up to the single cell level. With the CellHesion® technique, the adhesion of a single cell to any substrate can be measured and validated using comprehensive analysis tools. The Side-view cantilever holder enables a side view of the cell-sample interface while performing adhesion experiments, providing complementary information without expensive z-stacking.

The inherent drawbacks of traditional AFM imaging modes for fast imaging or for challenging samples like living cells can be impressively overcome by the NanoWizard® ULTRA Speed and QI™ mode. We present an enhancement of the AFM technique providing a versatile tool for extensive and convenient characterization of living cells.