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# NANOMECHANICS FROM ATOMIC RESOLUTION TO MOLECULAR RECOGNITION

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**INTRODUCTION:** The fields of scanning probe microscopy, molecular biology and information science have existed as individual disciplines for a long time, but only recently have moved closer to each other, as the nanometer scale has gained in importance. Biochemistry and molecular biology have moved to the nanometer scale from micrometer-sized objects such as cells, whereas physics and synthetic chemistry have extended investigations from atoms and molecules to the nanometer scale. Experiments in nano-scale science generate a wealth of data that has to be analysed and evaluated by means of modern information science. This is reflected by the interdisciplinarity in nano-scale research. A major tool to investigate the nano-scale is atomic force microscopy (AFM). Non-contact mode AFM is able to image surfaces with true atomic resolution, provided the interaction between surface and oscillated cantilever tip is controlled in an appropriate range. The cantilever *per se* is an excellent tool to study physical, chemical, and biochemical processes on the nano-scale. Molecules adsorbing on the surface of a cantilever produce an interfacial stress that leads to a bending of the cantilever, and to a shift in the resonance frequency of the cantilever owing to mass increase. Processes that generate heat cause a bending of a biomaterial cantilever because of differing thermal expansion coefficients of the two materials.

**METHODS:**

**RESULTS / DISCUSSION:**

*Cantilever Sensor Arrays as Chemical Sensors.*

Adsorption processes can be studied in various environments, such as gas flows, vacuum, and liquids. An array of individually functionalised cantilevers serves as a chemical multi-sensor, such as an artificial electronic nose, to characterize and recognize analytes, and to measure physical and chemical properties on the nano-scale. In a number of examples we demonstrate the application of cantilever arrays as gas sensors for solvent vapour detection, for medical applications, and as a sensor for quality control in a plasma cleaner environment.

*Cantilever Sensor Arrays as Biosensors in Liquids*

Biological and chemical processes in liquids can be transduced into nano-mechanical motion using a micro-fabricated silicon cantilever array. These sensors allow the rapid, quantitative and qualitative detection of non-labelled biomolecules in solution. We have used such sensors to detect sequence-specific DNA hybridisation with single base mismatch sensitivity. Single-stranded thiol-functionalized DNA 12-mers were anchored onto gold-coated cantilevers. Hybridisation with the respective complementary strand in buffer solution produced cantilever bending. A reference cantilever functionalised with a different oligomer sequence did not bend. The surface–solution equilibrium constant, as derived from concentration-dependent studies, was similar to the hybridisation efficiency in solution. We have explored the origins of the observed compressive surface stress using radiolabelled oligomers and various surface preparations. These studies suggest that the observed signal is predominantly due to steric crowding. We have also investigated the effect of ‘dangling ends’ upon hybridisation with complements that include a non-specific poly-adenine tail at either or both ends. Hybridisation again produced a compressive surface stress, and the magnitude of the signal was dependent on the position of the tail. Currently, we are scaling up the experiment to monitor eight cantilevers in an array to detect several sequences simultaneously.