CHEMICAL SENSORS AND BIOSENSORS IN LIQUID ENVIRONMENT BASED ON MICROCANTILEVERS WITH AMPLIFIED QUALITY FACTOR

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In an atomic force microscope (AFM), a micrometer-sized lever (transducer) bends as consequence of the interatomic force between a very sharp tip (sensing surface) and a sample (target). The cantilever deflection is measured with sub-angstrom resolution by a detector that typically consists of a laser beam reflecting off the cantilever into a segmented photodiode. Thus, forces of the order of 10 piconewtons can be measured. AFM provides the topography of organic and inorganic surfaces at atomic and nanometer scale in air, ultra high vacuum and in liquids. The large expansion of AFM techniques has widely benefited from the commercialization of microfabricated wafers composed of cantilevers of silicon or silicon nitride. This has brought about the birth of a new class of chemical sensors and biosensors based on microcantilevers.

In sensors based on microcantilevers, the cantilever is coated with a sensing film or receptor molecules. As a gaseous or liquid sample solution is flowed over the cantilever, the target molecules attach to the sensitized surface. The cantilever itself works like a transducer, thus in the microbalance method, the target substance is detected by a change of the cantilever mass, that gives rise to a change in the resonance frequency of the cantilever (AC-detection). In the surface stress method, only one side of the cantilever is coated with the sensing molecules. The surface stress of this side changes as the target substance adheres to the surface, producing a cantilever bending as the surface of this side expands or contracts to balance the surface energy change. The bending is measured by detecting the cantilever deflection (DC-detection). Sensors based on microcantilevers have been mainly developed for detection in a gas environment, giving a resolution in mass of ~1 pg, and a resolution in surface stress of ~1 mJ/m^2.

A new technique is presented for bio/chemical sensors, based on microcantilevers, for detection in liquid environment. The low quality factor of the cantilever in liquid is increased up to three orders of magnitude by using Q-control. This enables AC detection that is immune to the long-term drift of the DC cantilever response in liquids, and to temperature variations. This technique has been applied for the detection of ethanol in aqueous solution by using the microbalance method, and for antibody/antigen recognition by the surface stress method. The results show the feasibility and very high sensitivity of these novel devices.