MICROX II - A New Generation of Portable Measuring Systems for Microoptodes

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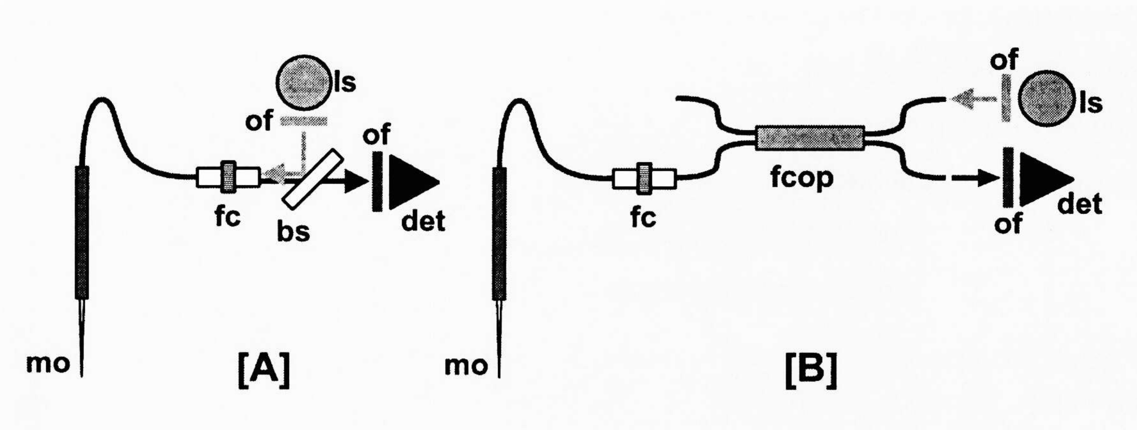
Summary

Sediments, microbial mats, biofilms and other microbial communities are characterized by steep gradients of physical and chemical parameters. Fibre optical microsensors, microoptodes, that we developed over the last three years have become powerful tools to investigate and measure these parameters with a sufficient spatial resolution and with a minor disturbance of the micro-environment in natural systems.

Together with microoptodes for oxygen[1], pH, temperature we developed a sensitive measuring system[2,3] that enables the measurement of luminescence intensities and lifetimes of indicators that are immobilized at the tip of tapered fibers.

As light sources, we used light emitting diodes, that nowadays are available with a high optical power output even in the blue part of the spectrum, where many indicators can be excited. Furthermore, LEDs are easy to modulate and thus enable both, the measurement of luminescence intensities independent of ambient light and the measurement of luminescence lifetimes based on a phase modulation technique. The weak amount of light emitted at the tip of a dip-coated silica-silica fibre required, however, a photomultiplier tube (PMT) as detector[2,3]. Although the PMTs are very sensitive light detectors, the application in natural systems for measurement of concentration profiles with and without strong ambient light causes additional noise problems with the PMT[3]. Therefore, we improved the composition of the sensing layer

that covers the tapered fibre tip and the taper geometry, because both have a large impact on the signal (see abstract of Kohls et al.). Furthermore, we improved the optical setup to reduce inherent coupling losses and inherent noise signals like unwanted additional luminescence caused by epoxy, solvents etc..



The figure above shows schematically the two principal optical setups that can be used for the application of microoptodes. Setup [A] consists of an excitation light source (ls), a LED, optical filters (of), a beamsplitter (bs), standard fibre connectors (fc) and the sensor, the microoptode (mo) and a PIN-photodiode detector (det). Setup [B] has a fibre coupler in place of the beamsplitter. To reduce the losses due to coupling, that usually amount to 50%, we applied wavelength selective coupling. In setup [A] the beamsplitter is a dichroic mirror and in setup [B] the coupler is a new device consisting of GRIN-lenses and a dichroic mirror. In case [B] we achieved a gain factor of 4 compared to the standard fibre coupler and in [A] the factor was between 8 and 10. This gain in optical signal together with the improved microoptode design enabled the use of photodiodes instead of PMTs.

We present the first all-solid-state instrument, MICROX II, that is based on the previously released portable instrument MICROX I, that uses a PMT as detector. Noise influences caused by additional luminescence in setup [A] and [B], and their possible reduction will be presented. Examples of first applications of the instrument will also be shown.

[1] „Fiber-Optic Oxygen Microsensors, a New Tool in Aquatic Biology“, I. Klimant, V. Meyer and M. Kühl, Limnology and Oceanography, Vol. 40 (6), 1995, pp. 1159-1165.

[2] "A Novel Measuring System for Oxygen Microoptodes", G. Holst, M. Kühl and I. Klimant, Chemical, Biochemical and Environmental Fibre Sensors VII, SPIE EUROPTO, Munich, Germany, 19-23 June, Vol. 2508, 1995, pp. 387-398.

[3] "A Microoptode Array for Fine Scale Measurement of Oxygen Distribution", G. Holst, R.N. Glud, M. Kühl and I. Klimant, Sensors and Actuators B, Vol. 38, 1997, pp. 122-129.