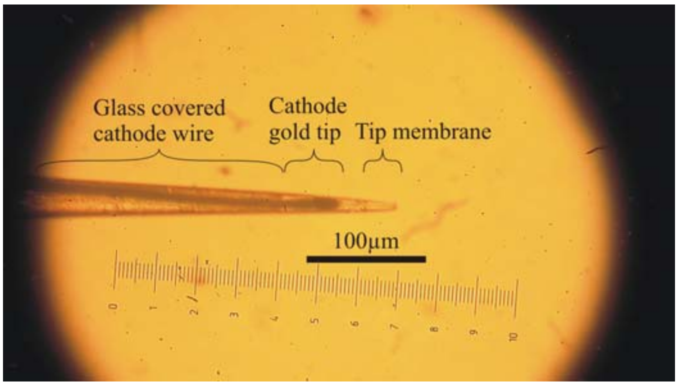
Tutorial 11: Application of microsensors in the marine environment

Lars R. Damgaard, PhD

Microsensors have been developed to measure a wide range of substances and parameters. Microsensors have a minute tip diameter, typically only 1/10 of the human hair.

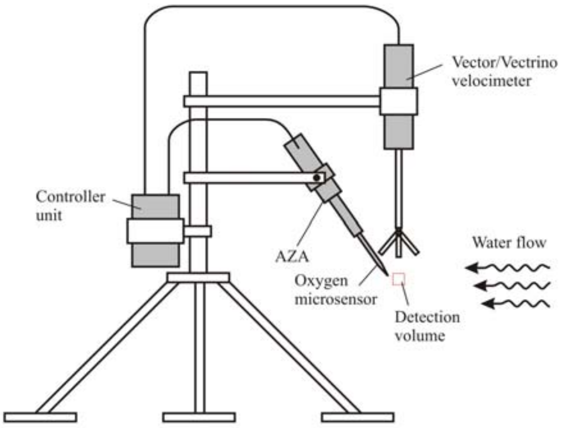


The small size gives the microsensors some extra-ordinary characteristics:

- they can penetrate into soft materials like seafloor sediment without disturbing the processes to be studied
- they can have a fast response (sub-second)
- they equilibrate with temperature very rapidly (sub-second)
- they consume very little analyte and are thus very insensitive to stirring
- they can work under extreme hydrostatic pressure (full ocean).

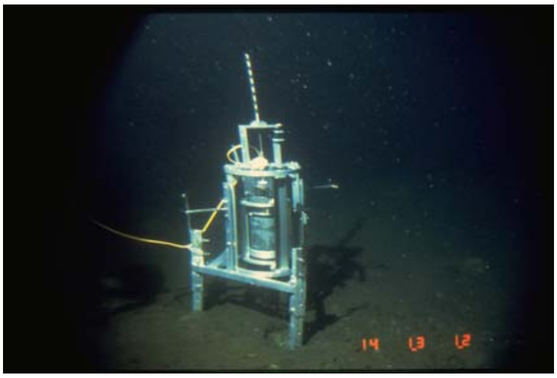
These characteristics make the sensors unique for a variety of applications in marine research and monitoring. The tutorial will explain in detail about

- The **eddy correlation technique** for oxygen flux measurements. This relatively new technique (Berg et al. 2003) relies on the simultaneous measurement of the fluctuating oxygen concentration and fluctuating vertical flow velocity in eddies to calculate the transport of oxygen between the water phase and the seafloor. This method requires very fast-responding oxygen sensors with a small physical layout, and Clark-type microsensors are currently the only sensors available that can meet these requirements. The theory behind the method and the instrumentation to implement it will be described.



- **Fast water column oxygen profiles**. Fast profiling oxygen measurements in the water column require sensors with a fast response to oxygen and with a fast temperature equilibration. The minute tip size of microsensors enables these features, and at the same time, the tiny tip membrane is very resilient to hydrostatic pressure. With pressure compensation, the sensors can work down to full oceanic depth. These features make oxygen microsensors ideal candidates for this application and the theoretical implications of this will be discussed.

- **Microprofiling** in seafloor sediments. Sediments are often highly stratified with layers with very different chemical conditions in close proximity. Microsensors allow the study of the distribution of chemical compounds in great spatial detail to elucidate the biogeochemical transformations in sediments.




Ultra-low oxygen measurements. Some areas of the ocean have such a low oxygen concentration that it can be difficult to determine whether it is actually zero. With micro-sensor technologies, it is possible to construct a sensor, which can intermittently block and un-block the access of oxygen to the sensor, which allows a detection limit of 5 nM ($1.6*10^{-4}$ mg/l). The sensor principle will be discussed and data presented.

References: Berg, P. et al. 2003. Marine Ecology Progress Series 261:75–83

The target audience of the half-day tutorial is the marine environmental monitoring and research community. The tutorial will aim to provide the audience a basic understanding of the theoretical and practical aspects of microsensor technology, and the possibilities and limitations in the different applications will be discussed. Various *in situ* instruments carrying microsensors will be displayed. The tutorial will include a practical demonstration, which allows the audience to get hands-on experience with the technology.

Presenters Bio – Lars R. Damgaard

Lars R. Damgaard made his Ph.D. thesis at the Department of Microbiology, University of Aarhus, Denmark, in 1997. After two years in a post.doc. position, Lars became a co-founder of Unisense A/S. Unisense is a company dedicated to providing microsensor technology to the world-wide scientific community, and Lars is responsible for the development of the electronics and in situ research equipment used in conjunction with Unisense microsensors. Furthermore, Lars has been the PI for Unisense on the COBO project, which is a EU project concerned with coastal benthic observatories as well as on a national Danish research project, BIOFLOW.

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