optiqua

MiniLab™

System Specification

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Introducing the Optiqua MiniLab

The Optiqua MiniLab is a compact sensing platform designed for label-free biosensing. It utilizes optical interferometry to detect refractive index changes taking place near the surface of an optical chip. The Optiqua MiniLab is delivered as a complete package including a fluidics system, electronics, an optical detection system and software. The sensor chip is housed in a cartridge (Figure 1) which is docked into the MiniLab to allow quick and easy loading and unloading of biosensor chips. The cartridge includes a microfluidic flow cell and the necessary electronic and optical connectors.

The Optiqua MiniLab is fully programmable in terms of pump rates and valve switching. The injection of the sample is done manually. Everything else, including the analysis of the results, is performed in the custom-designed software environment.

MiniLab features at a glance

- Sensing principle based on Mach-Zehnder interferometry.
- Versatile and complete sensing platform designed for biosensing applications.
- Fully programmable fluidic routing system.
- Includes analysis and control software.

Figure 1. *The MiniLab cartridge contains the optical chip and the microfluidic flow cell and is docked into the MiniLab system. The outer dimensions of the cartridge are 60x110x12 mm.*

Sensing Principle

The Optiqua MiniLab is a fiber optic interferometry sensing system utilizing the Mach–Zehnder interferometer (MZI) concept in a compact sensing platform. It is designed to detect and monitor real-time binding events at the molecular level. Quantitative, semi-quantitative and qualitative information of the analyte concentration can be obtained with MiniLab through appropriate assay development. MiniLab measures binding directly, by either rate-based (i.e., slope of the binding curve), or end-point-based (i.e., step response of the binding curve). The included software lets the user analyze the binding response with high sensitivity, thereby allowing real-time and in-situ monitoring of the chemical/bio-chemical interactions that take place on the chip sensing surface.

The Mach–Zehnder interferometer works as an optical scale, measuring differences in refractive index as seen by the sensing branch versus the reference branch. The basic layout of the MZI consists of an input channel wave-guide that splits up into two identical branches. After a well-defined length, these two branches are combined again to form the output wave-guide. Light that enters the input wave-guide splits equally over the two branches and combines again at the output wave-guide (Figure 3). The wave-guides are so called buried wave-guides in which the light travelling through the wave-guide is shielded from the environment via a top cladding. By using etching techniques, the top cladding is locally removed at a well-defined position above the waveguide in the sensing branch. In this so-called sensing window, the evanescent field of the light that travels through the under-laying channel wave-guide, extents into the environment above the sensor and becomes susceptible to changes in refractive index of the sample solution on top of the sensor window. The resulting change of the effective refractive index leads to a change of the speed of the light in the sensing branch and a change in the relative phase between light that has travelled through the sensing branch as compared to the reference branch. This change in relative phase leads to a change in the interference between light coming from the sensing and reference branch at the combining section and manifests itself as change in the output intensity of the MZI. The patented Optiqua sensor is an adaptation of the basic MZI design to improve the overall performance in terms of sensitivity, robustness and temperature independence.

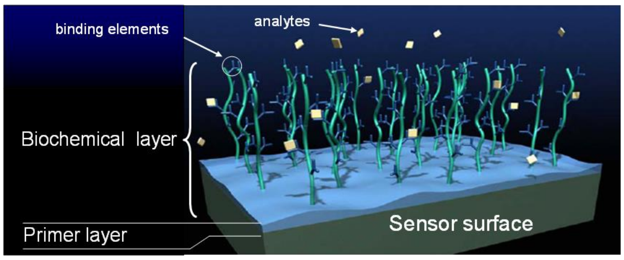

Figure 2. *Illustration of the biochemical interface developed for the MiniLab. The Si_3N_4 substrate is coated by a primer layer that protects the sensor surface and provides adhesion for the dextran hydrogel layer. The dextran is functionalized with bio-active receptors or ligands, which can be selected depending on the application.*

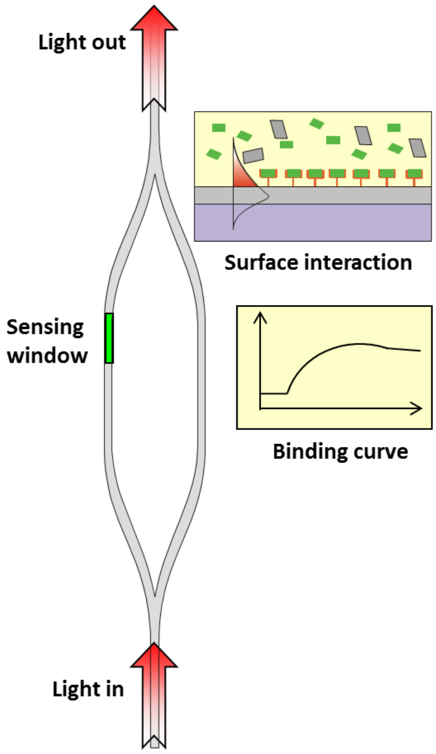

Figure 3. *The Mach-Zehnder interferometer (illustrated above) allows for robust refractive index sensing. Combined with an appropriate surface chemistry and receptor system, the MiniLab can detect and quantify analytes with high sensitivity and selectivity.*

Sensor Chip

The MiniLab sensor chip is the heart of the technology for MiniLab platform. The chip surface, composed of Si_3N_4, is coated with a dextran layer. The dextran hydrogel layer forms a hydrophilic environment for attached bio-receptors or ligands, preserving them in a non-denatured state. The hydrogel also facilitates high surface loading and limits non-specific binding. The receptors/ligands are attached to the dextran layer via covalent chemical bonds. In between the Si_3N_4 sensing surface and the dextran layer, there is a proprietary primer layer that has been developed by Optiqua, providing a stabilized Si_3N_4 surface suitable for prolonged exposure to the aquatic environment (Figure 2).

Applications

A potential application of the Optiqua MiniLab is a competition (inhibition) assay to determine the concentration of a low molecular weight contaminant in a sample. A derivative of the target analyte is first immobilized on the surface of the MiniLab chip, and the sample to be tested is mixed with an antibody specific to the target analyte. After incubation, the solution is injected into the MiniLab and the resulting binding response is measured. If the analyte concentration is high in the sample, a large proportion of the antibodies will be occupied by the target molecule and unable to bind to the surface of the MiniLab chip. An illustration is shown in Figure 5. In this application, conditions that allow mass-transport limited binding may be beneficial, as the binding rate then becomes directly proportional to the concentration of free antibody. The response is compared with a calibration curve and the concentration of analyte in the original sample can be determined. The total time of the injection and analysis of a sample, from start to finish, is less than 10 minutes. The outcome is immediately reported on the computer screen (Figure 4).

The example above is just one of many potential applications of the MiniLab. Being a refractive-index sensitive method, the biosensing principle used in the MiniLab has similarities with other optical biosensing methods, such as surface plasmon resonance. The same types of applications and methods can be developed for the MiniLab system as well.

Optiqua has extensive know-how and experience in developing suitable surface chemistries and assay formats for the MiniLab. We would be happy to discuss applications with you!

Selected applications

- Sensitive detection of contaminants.
- Non-labelled biosensing for analyte concentration determination.
- Affinity/binding analysis of biomolecules.
- Surface science and characterization of novel surface chemistries.

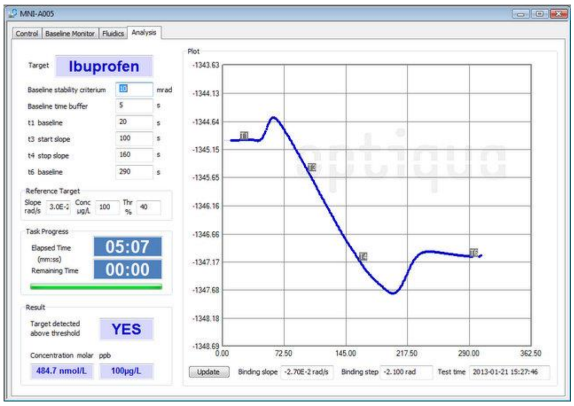

***Figure 4.** Screenshot of the custom-developed software for Optiqua MiniLab.*

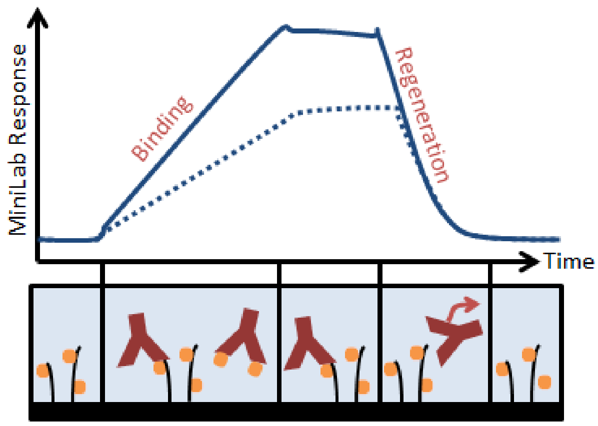

***Figure 5.** Typical binding curves of an inhibition assay. The solid line shows a high binding response (low target concentration) while the dotted line shows a lower binding response (higher target concentration).The cartoon underneath illustrates the stages of the assay.*

Technical Specifications for Optiqua MiniLab

Fluidics	
Pump	Single syringe infusion/withdrawal syringe pump. Pumping rate: from 3 uL/h to >100 mL/h depending on syringe dimensions; with default syringe the typical rate is 1 mL/h.
Syringe (for pump)	Hamilton Gastight 1002, 2.5 mL glass syringe (default). Other syringes can easily be mounted to achieve desired flow rates and/or capacities.
Injection Valve	Motorised injection/switching valve (2-position, 6-port). Port-to-port volume 660 nL. Wetted material: PEEK. Maximum working pressure: 35 MPa (5000 psi).
Switching Valve	2-position switching solenoid-operated isolation valve (for automatic refilling of running buffer). Wetted material: PTFE.
Tubing	1/16" OD tubing, ID: 0.01" (0.254 mm) and 0.03" (0.762 mm).
Injection Loop	50 μL as default (can be changed as required). Recommended injection volume: 150 μL (for 50 μL loop).
Fluidic Connectors	Standard Rheodyne (IDEX) 1/16" connectors. Material: PEEK
Microfluidic Flow Cell	Linear rectangular microfluidic channel, 12.5 mm long, 0.5 mm wide and 0.025 mm high. The walls of the flow cell are made of chemically resistant fluoroelastomer.
Control System	Computerized programmable control system, allowing control of valve switching and flow rate. The control system is integrated in the MiniLab software.

Optics	
Light Source	850 nm Vertical Cavity Surface Emitting Laser (VCSEL), low power output.
Detector	Monolithic photodiode with on-chip transimpedance amplifier.
Optical Resolution	Optical resolution: The theoretical minimum optical resolution is $4.6*10^{-8}$ RIU (refractive index units). Practical minimum optical resolution: the practical optical resolution is at least 10^{-7}RIU.

Electronics	
Power Requirements	AC powered 100 to 240 VAC, 50/60 Hz.
I/O interface	USB connection.
Computer Requirements	Desktop or laptop computer running MS Windows.
Software	Optiqua's custom developed MiniLab control and analysis software will be installed on the computer.

Contact

For more information on Optiqua MiniLab, or other Optiqua products, please contact us by email or call us at one of the following numbers.

Optiqua Technologies Pte. Ltd.

Website: www.optiqua.com

Email: Info@optiqua.com

Asia Pacific Office

82 WaterHub, Toh Guan Road East, #C2-11/1

Singapore 608576

Tel: + 65 68969196

Europe Office

Hengelosestraat 705, 7521 PA Enschede

The Netherlands

Tel: + 31 (0) 534836377