A SPIRAL-SHAPED MACH-ZEHNDER INTERFEROMETRIC SENSOR FOR MONITORING THICKNESS CHANGES IN BIORECEPTOR LAYERS

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Introduction:

The potential of the classical "straight" integrated optical Mach-Zehnder interferometric (IO-MZI) sensor for monitoring thickness changes in bioreceptor layers is large: the achieved resolution in refractive index changes obtained in the past is as low as $\delta n \sim 10^{-8}$ [1], see Fig. 1. The MZI can be made selective after definition of sensing windows in the top cladding and by adding a target specific bioreceptor layer on one branch. The high resolution is a result of firstly the fact that the two branches of the device are made as equal as possible to minimise the effect of fluctuations in temperature, and secondly the use of electro-optical (EO) modulation. The EO-modulation enables the detection of a full response curve, including those parts of it that lead to a high sensitivity. As a result, the change in effective index (caused by a change in thickness of the bioreceptor layer) determined from the change in phase of the response curve is insensitive for fluctuations of the light source power.

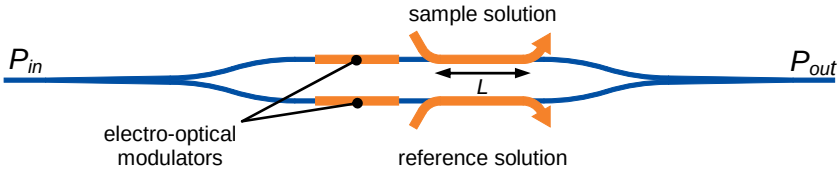

Figure 1. Top-view of a classical "straight" IO-MZI.

Spiral-shaped MZI layout:

A spiral-shaped MZI (sMZI) layout is particularly suitable for integration into multi-sensing arrays, mainly owing to device compactness, which also makes the device less vulnerable to process non-uniformities.

The goal of the running project [2] is to realise a multi-sensing array by placing sMZIs in series to form a sensing branch, and to place several sensing branches in parallel, as is illustrated in Fig. 2. In such an arrangment it is possible to use a single light source for several sensors. Each sensor will contain an EO-modulator, which makes it possible to separately interrogate and accurately read-out each sensor in such a sensing branch simultaneously. The layout (area 1×1 cm^2) enables relatively long interaction lengths of several tens of cm and ideally leads to an insensitivity for changes in temperature or temperature gradients.

A parametrised sMZI has been designed such that all changes in waveguide slope and curvature are continuous.

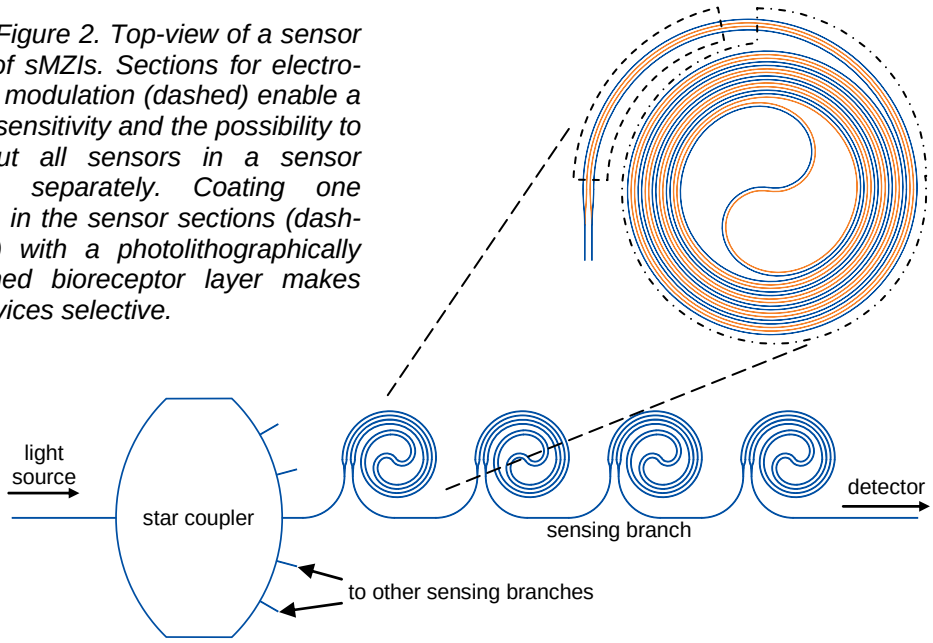

Figure 2. Top-view of a sensor array of sMZIs. Sections for electro-optical modulation (dashed) enable a larger sensitivity and the possibility to read-out all sensors in a sensor branch separately. Coating one branch in the sensor sections (dash-dotted) with a photolithographically patterned bioreceptor layer makes the devices selective.

Photolithographically patterned bioreceptor layers:

The sensors can each be coated with *e.g.* a target specific bioreceptor layer to enable the detection of changes in concentration of a certain target like a virus or an enzym. In this project, technology has been applied for the immobilisation and photolithographical patterning of such bioreceptor layers, which should result in a demonstrator to monitor the ripening process of cheese by measuring changes in the concentration of several different enzymes involved in this process [3].

Concluding remarks:

A spiral-shaped MZI (sMZI) is being developed having the following features:

- insensitivity for changes in temperature and temperature gradients;
- compact device layout, enabling
- cascading of the devices for multisensing purposes.

The latest results will be shown during the conference.

[1] R.G. Heideman, P.V. Lambeck, “Remote Opto-Chemical Sensing with Extreme Sensitivity: Design, Fabrication and Performance of a Pigtailed Integrated Optical Phase-Modulated Mach-Zehnder Interferometer System”, Sensors and Actuators B61, pp. 100 – 127, 1999.

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[3] Biomaterials and immobilisation protocol: courtesy of IMEnz Bioengineering B.V., Groningen, The Netherlands.