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Silicon-on-Insulator as a Platform for Biosensors

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Silicon-on-Insulator (SOI) is a very interesting material system for highly integrated photonic circuits. The high refractive index contrast allows photonic waveguides and waveguide components with submicron dimensions to guide, bend and control light on a very small scale so that various functions can be integrated on a chip. Moreover, SOI offers a flexible platform for integration with surface plasmon based components which in turn allows for even higher levels of miniaturization. Key property of both waveguide types is the mode distribution of the guided modes: a high portion of the light is concentrated outside of the core material, thus making them suitable for sensitive detection of environmental changes.

Using Silicon-on-Insulator also has some technological advantages. Due to the CMOS industry silicon technology has reached a level of maturity that outperforms any other plane chip manufacturing technique by several orders of magnitude in terms of performance, reproducibility and throughput. All current fabrication techniques are compatible with CMOS frontend fabrication methods, all our devices have been fabricated using Deep-UV Lithography.

There are also strong economic arguments supporting the use of Silicon-on-Insulator for integrating nano-photonics structures and devices. Nanophotonic IC are fabricated with wafer scale-processes which means that a wafer can contain an enormous amount of structures. Combined with the fact that large SOI wafers are commercially available at a relatively moderate cost, this means that the price per chip can be very low. This is a significant advantage when producing sensors since one can even choose to use disposable chips.

We illustrate chemical and label-free molecular biosensing with SOI microring resonator components. In these microring resonator sensors, the shift of the resonance wavelength is measured. A ring of radius 4 μm is capable of detecting bulk refractive index changes of 10^{-5} RIU (Refractive Index Units), approaching the literature stated limit of 10^{-6} for biomolecular sensing. We describe the integration of surface plasmon waveguides with SOI waveguides and discuss the principle of a highly sensitive and compact surface plasmon interferometric sensor suitable for biosensing.

The device is two orders of magnitude smaller than current integrated SPR sensors, and has a highly customizable behaviour. We obtain a theoretical limit of detection of 10^{-6} RIU for a component of length $10\ \mu\text{m}$. We address material issues and transduction principles for these types of sensors. These devices have been fabricated and preliminary measurements show the validity of the surface plasmon interference principle.



Research Meeting
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5. Biosensors

This SRA is focused on the field of biosensors. Such devices use specific biochemical reactions mediated by enzymes, immunosystems, tissues, organelles or whole cells, even bacteria, fungi and yeast, to detect chemical compounds, usually by electrical, thermal or optical signals. Biosensors are typically classified by the type of recognition element or transduction element employed.

The first SRA 5 Meeting took place on May 2-3, 2007 in the SAS Radisson in Basel with participants from 5 FRONTIERS partners. After a few short presentations introducing the participants' research activities, available facilities and resources, all participants were asked to write down three key issues related to the field of biosensors considered important. The sheets were collected and grouped into greater topics. The participants agreed to select two of the topics for an extended discussion. For each topic, one person volunteered as animator for a discussion in a smaller group of people. In each group, somebody was appointed rapporteur summarizing the discussion.

The next day the rapporteurs presented the results of the discussions to the plenum.

Then the brainstorming session was repeated with new topics and newly constituted groups fostering communication, collaboration and scientific exchange, and again summarized.

Biosensors is a very rich field, as it contains many aspects, such as fabrication, application, methods, techniques, sensitivity issues, medicine, biochemistry etc. Further SRA 5 meetings could include input from external experts to topics/issues previously identified.

Lectures:

- Natalia Nugaeva, AFM-based biosensors for microorganism detection
- Ganeshram Krishnamoorthy, Biosensing - A New Lab on a Chip Approach based on Surface Plasmon Resonance Imaging
- Ann Vinckier, Development of a Biosensor for Life Science Applications: Needs of the Biotech Industry
- Simon Rast, Magnetic resonance force microscopy under UHV-conditions
- Kristien Bonroy, Functionalized nanoparticles for biomedical applications
- • Peter Debackere, Silicon-on-Insulator as a Platform for Biosensors
- Chris Lee, The Chemical Nose

Posters:

- Natalija Backmann, Microcantilever-based biosensor for label-free detection of proteins
- Thomas Braun, François Huber, Murali Krishna Ghatkesar, Natalija Backmann, Hans Peter Lang, Christoph Gerber, and Martin Hegner, Processing of kinetic microarray signals