Silicon-on-Insulator Microring for Label-Free Biosensing

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Introduction and motivation

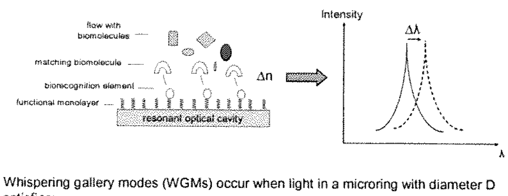
We develop a label-free biosensor, which directly detects a molecule binding to a receptor fixed on the sensor's surface.

Optical microcavities combine high sensitivity to surrounding changes with small dimensions, so they can be used for fast, sensitive and quantitative sensing of biomolecular binding in small amounts of analyte.

The fabrication of Silicon-On-Insulator microring with deep-UV lithography is suitable for cheap mass-fabrication needed for commercial applications.

Application areas: bacterial and virus detection, medical diagnostics, drug development, food and environmental control

Principle of biomolecular sensing with optical microcavities

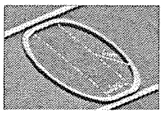


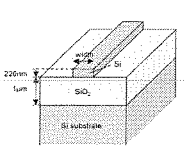
Whispering gallery modes (WGMs) occur when light in a microring with diameter D satisfies:

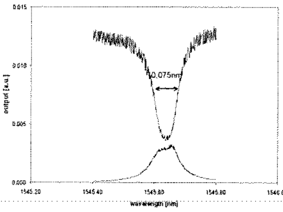
$$\lambda_{resonance} = \frac{n_{eff}\,\pi D}{m}, \quad m = 1, 2, \ldots$$

Binding of biomolecules to the modified sensor's surface causes a measurable shift of the resonance wavelength due to a changing refractive index.

SOI ring resonators fabricated with Deep-UV lithography



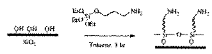




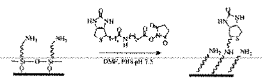
Pass and drop transmission spectra of the racetrack resonator, with Q factor of about 20,000. The fluctuations are due to the nonoptimal antireflective coating of the sample facets.

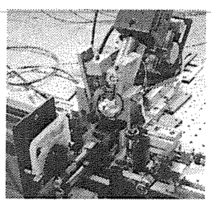
Silicon surface modification

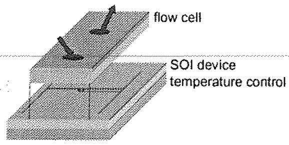
1. Cleaning and oxidation of the silicon surface
2. Silanization: surfaces are immersed in 50 mM APTES (3-aminopropyltriethoxysilane) in toluene. APTES is used to functionalize the silicon surfaces since it acts as a bridge between biomolecules and dielectrical surfaces such as silicon.



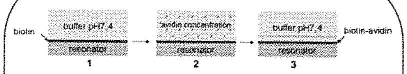
3. Biotin conjugation: biotin carrying an activated ester functionality (Biotin-LC-NHS) is chemically bound by reaction with the amino-functionalized surface.

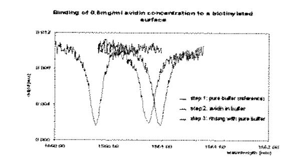






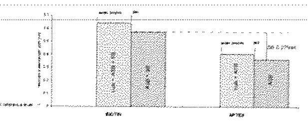
Avidin-biotin binding tests



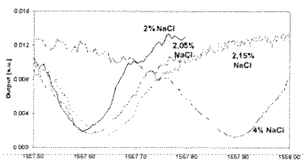


Main problems:

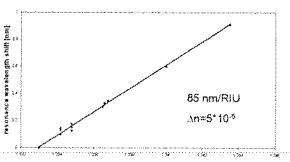
- aspecific binding due to non-optimized chemistry
- homogeneity of the functional layer



Bulk sensing experiments



Measured pass-spectra of a SOI ring, immersed in liquids with different refractive indices.



Resonance wavelength shift for changing refractive index units.

Conclusion and perspectives

SOI microrings fabricated with deep-UV lithography are suitable for sensitive biosensing. The silicon surface modification requires non-trivial chemistry and characterization techniques.

Bulk sensing experiments show a limit of detection of $5 \cdot 10^{-5}$ Refractive Index Units (RUI) with a 5 micron racetrack resonator. With use of the avidin-biotin system, protein binding detection is proved.

This integrated SOI biosensor will be lined up in arrays for a proof-of-principle biosensor for multiparameter analyses.

NanoBio Europe 2006
Posters list

1. µTAS, integrated systems

1	**Evanescent field excitation as a simple scheme for quantification of low amounts of DNA**	KOLARI	KAI	VTT	Finland
2	**A magnetic micro-actuator for biomolecule capture and manipulation**	ROSTAING	HERVE	Tyndall National Institute	Ireland
3	**EWOD based actuation for integrating complex biological protocols (DNA repair, PCR) on lab on a chip.**	RUANO	JESUS	Ikerlan S.Coop.	Spain
4	**Low cost portable transducer**	SEILER	ANNE-LAURE	CEA	France

2. Biosensing

5	**Poly(3,4-ethylenedioxythiophene) based biosensor**	ALI	EMRIL	Institute of Bioengineering and Nanotechnology	Singapore
6	**MARS: A non-contact acoustic sensor and its new approach to Biosensing.**	ARAYA-KLEINSTEUBER	BERNARDITA	University of Cambridge	United Kingdom
7	**Construction of a lipid biochip and characterization of the cytochrome-c thiol/lipid mixed bilayer interactions**	BAPTISTA	MAURICIO	UNIVERSITY OF SAO PAULO	Brazil
8	**Identification of heptapeptide motifs specifically binding**	CHEN	HAIBIN	National University of Singapore	Singapore
9	**Self-assembled monolayers on glass for combinatorial (bio)sensing and (nano)fabrication**	CREGO CALAMA	MERCEDES	University Twente	Netherlands
10	**Development of Novel Technologies for Species Differentiation and Food Authentication**	CURTIN	MAEVE	Tyndall National Institute	Ireland
11	**Silicon-on-Insulator Microring for Label-Free Biosensing**	DE VOS	KATRIEN	Ghent University Information Technology	Belgium
12	**Quantitative biosensing of thermal denaturing of proteins adsorbed to nanoparticles**	FORREST	JAMES	University of Waterloo	Canada
13	**Indium-tin oxide thin electrode films as a versatile substrate for applications in optical and electrochemical biosensors.**	GALVIN	PAUL	Tyndall National Institute	Ireland
14	**Temperature detection of biochips using impedance measurements of solid/liquid phase transition**	GHEORGHE	MARIN	Tyndall National Institute	Ireland
15	**Carbon-Nanotube Based Nanobiosensors: voltammetric test and Fe +3 detection in clinical usage**	HAJIZADEH	SOLMAZ	University of Mazandaran	Iran
16	**Nanostructured molecularly imprinted polymers for biosensor applications**	HAUPT	KARSTEN	Compiègne University of Technology	France
17	**Direct proteins and protein-polymer macromolecular complexes entrapment at a PDMS surface for immuno-biochips development**	HEYRIES	KÉVIN	Université Claude Bernard-Nanospad	France
18	**Enhanced SPR Biointerface Sensitivity via Nano Surface Corrugations and Patterned Immobilization for Rapid Sepsis Biomarker Detection.**	HOA	XUYEN D	McGill University	Canada
19	**A Biosensor System Based on Thermally Blocked Magnetic Nanoparticles**	ILVER	DAG	Imego AB	Sweden
20	**Detection of antibody-antigen interactions via the Magnetic Acoustic Resonator Sensor**	KIOUPRITZI	ELEFTHERIA	University of Cambridge	United Kingdom
21	**Gold Nanorings for High Sensitivity Optical Biosensing**	LARSSON	ELIN	Chalmers University of Technology	Sweden
22	**DNA biosensor: study of the hybridization of Nanogold® labelled hairpin probes grafted on a semi-conductor electrode**	LAVALLEY	VIRGINIE	LMGP (ENSPG)	France
23	**Mesoporous gold electrodes for measurement of electrochemical double layer capacitance**	MARTIN	DONALD	University of Technology, Sydney	Australia
24	**Nanobiosensors based on individual olfactory receptors**	MINIC	JASMINA	INRA	France
25	**Molecular Nanocrystals grown in Sol-gel thin films for Chemical and Biological Sensor Applications**	MONNIER	VIRGINIE	CNRS Grenoble	France
26	**Periodically segmented waveguide Fabry-Perot interferometer for bio/chemo sensing**	NATHAN	MENACHEM	Tel Aviv University	Israel
27	**Preparation of Carbohydrate Microarrays by Immobilization of Multivalent Neoglycopeptides on Glass Slides Through Oxime Ligation**	OLIVIER	RENAUDET	University Joseph Fourier - LEDSS	France
28	**Novel phosphate-phosphonate hybrid nanomaterials, applied to biotechnologies.**	PETIT	MARC	University of Nantes	France
29	**Proteins, nanocrystals and hybrid systems**	to confirm POMPA	PIER PAOLO	National Nanotechnology Laboratory of INFM-CNR	Italy
30	**Use of ion exchange waveguides to enhance the performances of an array biosensor.**	RÉMI	GALLAND	CEA Grenoble	France
31	**Application of nanotechnologies in electrochemical biosensors**	RISHPON	JUDITH	Tel-Aviv University	Israel
32	**Novel gene sensors based on conjugated polymers and nanoparticles**	TRAVAS-SEJDIC	JADRANKA	The University of Auckland	New Zealand
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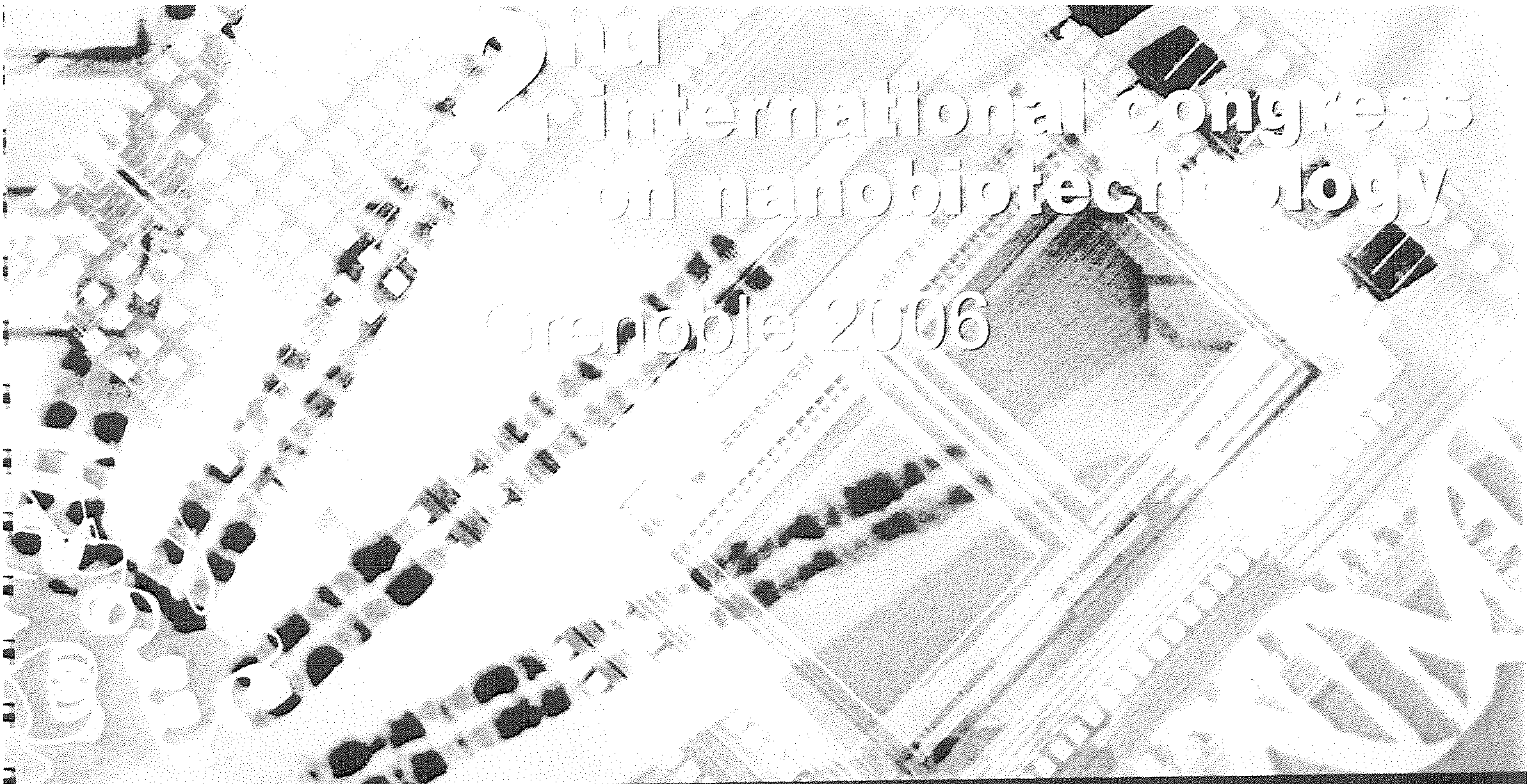
34	**Spectroscopic analysis and AFM-fluorescence imaging of Mycobacteria KMS**	ZHOU	ANHONG	Utah State University	United States

3. Cell analysis and manipulation



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