Fraunhofer IPMS

Photonic Biosensors

Development of a photonic biosensor system for the analysis of biomolecules in liquids

The goal of this work is the development of novel label-free biosensors based on silicon nitride (Si_3N_4) photonic integrated circuits (PICs) that can detect a wide range of biomolecules in liquids. A particular focus is on medical applications, especially the detection of biomarkers indicative of neurodegenerative diseases (NDDs).

On-chip integration of high-precision, low-loss, and high-density waveguide-based Si_3N_4 sensor concepts, such as those based on microring resonators (µRR) and Mach-Zehnder interferometers (MZI), in combination with specific surface biofunctionalization and antigen molecule immobilization strategies, is expected to lead to high-performance photonic biosensor systems in terms of sensitivity, multiplexing, and miniaturization.

Photonic Biosensor System

The development includes all basic technological modules: photonic devices, microfluidics, surface biofunctionalization and system integration.

- Si_3N_4 waveguide platform on 200 mm Si wafers
- Multiplexed µRR-based biosensors at 1550 nm
- Multiplexed MZI-based biosensors at 850 nm - to optimize
- performance (sensitivity) and on-chip hybrid integration
- Microfluidic system and chip fluidic cell assembly
- Biofunctionalization of the sensor surface
- Novel capture DNA probes and biological binding assays
- System integration and proof-of.concept demonstration

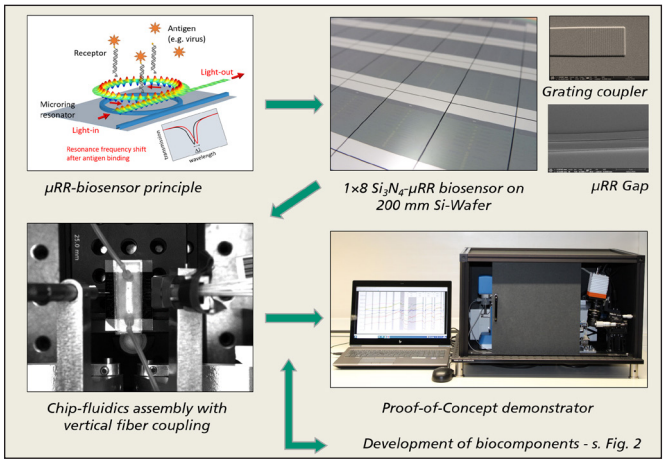

Fig. 1: Development steps for the photonic biosensor technology

Biomarker Detection

The developed biosensors were evaluated for the detection of microRNA biomarkers (miRNAs). The miRNAs are considered promising biomarkers for the diagnosis of cancer or NDDs such as Alzheimer's or Parkinson's disease. Since disease diagnosis based on these biomarkers is specific to each individual patient, this need for personalized diagnosis is time-consuming and expensive for technologies such as ELISA or PCR.

This is where the developed photonic sensor technology can help. The results show that the developed multiplexed μRR biosensors can rapidly detect multiple specific miRNA biomarkers in parallel.

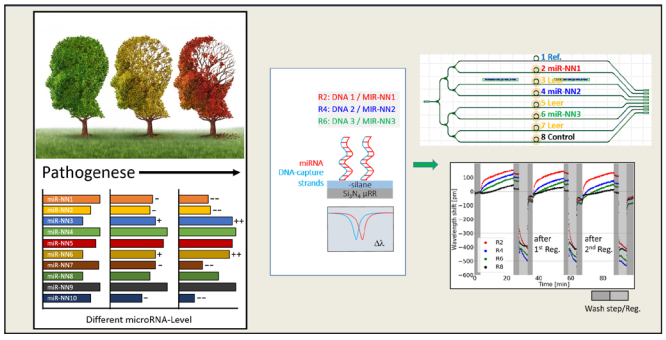

Fig 2: miRNA levels indicative of NDDs and their pathogenesis. Experimental data showing successful parallel detection of 3 different miRNAs using the developed μRR sensor. Successful sensor surface regeneration approach developed at MEOS.

In summary, the results demonstrate the potential of:

- miRNA detection as an indication for NDDs
- Multiplex fingerprintings of NDD-indicating miRNA
- Chip regeneration and hence cost reduction for the detection method

R&D Offer

- **Unique selling points of photonic sensing method:** label-free, multiplex, sensitive, fast result; scalable through
- wafer-level fabrication; application-specific bioprotocols;
- miniaturization through photonic integration
- **One-stop-shop** for silicon-based PIC sensor development for biomedical applications
- PIC sensor concepts as versatile **»plug-and-play« system**
- for a broad analyte spectrum, for PoC, personalized diagnostics
- **Si_3N_4-on-Si PIC technology platform** for various applications - biomedical, environmental monitoring, telecommunications, spectroscopy, quantum technology.

Contact

Dr. Florenta Costache
florenta.costache@
ipms.fraunhofer.de

Dr. David Smith
david.smith@
izi.fraunhofer.de

Fraunhofer Center for Microelectronic and Optical Systems for Biomedicine (MEOS)

www.meos.fraunhofer.de/en