Silicon photonic supported by dielectrophoresis for detecting microbes.

Anders Henriksson [1], Madeline Altmann[1], Peter Neubauer[1], Mario Birkholz[2]

henriksson@tu-berlin.de

[11]Technische Universität Berlin, Institute of Biotechnology, Chair of Bioprocess Engineering, Straße des 17. Juni 135, 10623 Berlin, Germany

[2] IHP – Leibniz-Institut für innovative Mikroelektronik, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Keywords: cell-based diagnostics, dielectrophoresis, silicon photonic, microring resonator

Introduction

The effect of diffusion and mass transfer limitations in receptor-based biosensors become particularly significant when attempting to register larger bioparticles such as whole cells and bacteria, since few analytes are present in the sample solution and these binds less efficiently to the sensor surface. The target cells are generally delivered to the sensors via microfluidic solutions with microchannel heights of tens to hundreds of micrometres; consequently, most cells will pass the microchannel without adsorption on the sensor surface.[1] An applied AC field will interact with the cells and may be used to focus them onto a sensor surface via the dielectrophoretic force. In this work we have applied dielectrophoresis to focus microbes onto a silicon based microring resonator biosensor to increase its sensing performance

Results and Discussion

We designed a chip with silicon photonic integrated circuits (PIC) based on the IHP technology to realize a sensitive microring resonator that can be used for sensing purposes. FEM simulations allowed us to optimize electrode structures next to the waveguides that is used to focus the cells onto the core waveguide.[2] Based on the simulations the electrodes were realised with doped silicon structures on the device layer separated 1.5 µm from the core waveguide. The packaging of the chips whose dimension is only 2.5x2.5 mm and contains wire bonds, grating coupler and sensing areas was realised with a combination of lithography techniques as well a PDMS chip. As a model organism to detect, Legionella Parisiensis was chosen.

An applied voltage of 10 Vpp at 20 MHz frequency was identified as parameters that may focus living cells while not interacting with pathogenic irrelevant dead cells.

Furthermore, proof of principle measurements showed successful detection of the cells with the microring resonators causing the resonance peaks to shift to higher wavelengths.

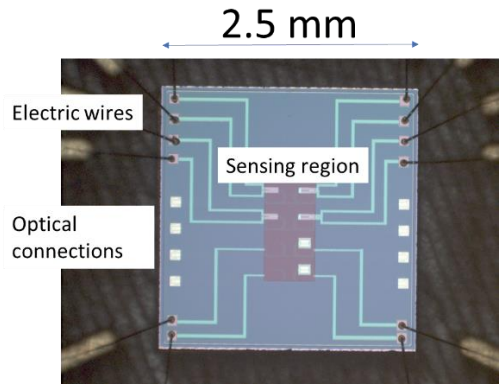

Figure 1: *The designed sensor Chip.*

Conclusions

We have explored the implementation of DEP in silicon photonic biosensors for detecting whole legionella cells. Suitable designs and electric parameters have been identified and proof of principle experiments show that microring resonator might be suitable for detecting legionella in drinking water.

References

[1] Henriksson, A.; Neubauer, P.; Birkholz, M. *Biosensors* **2022**, *12*, 784 https://doi.org/10.3390/

[2] Henriksson, A.; Kasper, L.; Jäger, M.; Neubauer, P.; Birkholz, M. *Micromachines* **2020**, *11*, 954. https://doi.org/10.3390/mi11110954

Acknowledgements

This work was funded by the German Federal Ministry of Education and Research (BMBF) within the program “Wissenschaftliches Vorprojekt Photonik” (FKZ 13N15712).)