Preparation of photonic biosensors by inkjet printing technology


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Abstract

In order to enable local functionalization of label-free optical waveguide biosensors in a cost effective mass-fabrication compatible manner, we investigate surface modification employing inkjet printing of a functional polymers (biotin-modified polyethyleneimine (PEI-B)) to implement high receptor densities at the surface and b) UV-curable benzophenone dextran (benzox-dextran) to form a voluminous porous hydrogel matrix. The combination of these approaches on a single chip is promising for the detection of biomolecules. We evaluate these functional polymers and hydrogels on an integrated four-channel silicon nitride (Si₃N₄) waveguide based Mach-Zehnder interferometric (MZI) sensor platform operating at a wavelength of 850nm (TM-mode).

Evanescent wave sensing

Detection principle

The binding of biomolecules to the functionalized sensor surface induces a local refractive index change that influences the light propagation in the waveguide. This leads to a phase shift between sensing and reference arm, which is translated into a sinusoidal modulation of the output power at the output of the MZI sensor [1].

Surface modification

To enable biomolecular measurements, we developed inkjet printing procedures both for functional polymers (biotin-modified polyethyleneimine (PEI-B) macromolecules) and for hydrogel precursor solutions (benzophenone modified dextran (benzox-dextran)) [3]. This allows the local functionalization of sensing waveguides in a cost effective and mass-fabrication compatible manner.

Results

Hydrogel modification

1) AFM-study towards swelling

Hydrogels show a substantial uptake of water upon immersion in aqueous solutions, resulting in extensive swelling. The swelling behaviour of printed hydrogel films was investigated with AFM-measurements conducted in different buffers and air on two equally printed hydrogels layers. A swelling ratio of 7.5±1.5 and a thickness of 1000±300nm of the swollen film above the waveguide was determined.

2) Streptavidin binding on MZI

MZI-sensors were modified with the three different hydrogel-containing surfaces (A1, A2 and B2) and streptavidin binding measurements were performed. For the surface A1 and B2, signals of 14.5±1.2m (n=4) and 12.6±1.5m (n=4), respectively, were measured, proving the ability of streptavidin i) to diffuse through the hydrogel and ii) to bind to within the hydrogel-matrix. Surface A2 - containing both surface bound and hydrogel bound PEI-B - lead to an increased response of 18.5±1.2m (n=4).

References