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Optical Sensing in Microchip Capillary Electrophoresis by Femtosecond Laser Written Waveguides

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Capillary electrophoresis separation in an on-chip integrated microfluidic channel is typically monitored with bulky, bench-top optical excitation/detection instrumentation. Optical waveguides allow confinement and transport of light in the chip directing it to a small volume of the microfluidic channel and collecting the emitted/transmitted radiation. However, the fabrication of optical waveguides or more complex photonic components integrated with the microfluidic channels is not a straightforward process, since it requires a localized increase of the refractive index of the substrate.
Recently, a novel technique has emerged for the direct writing of waveguides and photonic circuits in transparent glass substrates by focused femtosecond laser pulses.
In this work we demonstrate the integration of femtosecond laser written optical waveguides into a commercial microfluidic chip. We fabricate high quality waveguides intersecting the microchannels at arbitrary positions and use them to optically address with high spatial selectivity their content. In particular, we apply our technique to integrate optical detection in microchip capillary electrophoresis. Waveguides are inscribed at the end of the separation channel in order to optically excite the different plugs reaching that point; fluorescence from the labelled biomolecules crossing the waveguide output is efficiently collected at a 90° angle by a high numerical aperture optical fiber. The sensitivity of the integrated optical detection system was first evaluated filling the chip with a dye solution, obtaining a minimum detectable concentration of 40 pM.
After dynamic coating of the microchannels with an EPDMA polymer we demonstrate electrophoresis of an oligonucleotide plug with concentration down to 1 nM and wavelength-selective monitoring of on-chip separation of three fluorescent dyes. Work is in progress on separation and detection of fluorescent-labeled DNA fragments, targeting specific, diagnostically relevant regions of a template DNA, for application to the detection of chromosome aberrations.

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