Optical integration for microfluidic systems

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Summary

Integrated optical waveguides offer great potential for constructing sensors and sorters for integrated optofluidic devices in low-cost on-chip systems. Progress towards optical integration for bioanalysis will be discussed, with examples in key applications, and challenges and opportunities will be described.

Introduction

Optical waveguides are ideal structures for the integration of advanced optical functions in microsystems. Microfabrication of optical waveguides enables low-cost mass-production of compact, robust, multianalyte chemical sensor chips. The fabrication techniques which revolutionised electronics, making possible hugely complex microelectronic systems at very low cost, are enabling a similar transformation in optical devices. This renders optical circuits particularly well suited to mass-produced bio/chemical sensor arrays exploiting surface chemistry, optical cell-sorters which discriminate on the basis of optical properties and for integration in microfluidic systems for advanced micro-cytometry.

Trapping and propulsion

Optical tweezers are well-established as a tool for non-contact, non-destructive handling of biological materials. Recently, interest has grown in optical manipulation at surfaces [1] as part of the toolbox of the "lab-on-a-chip". In particular, advances have been made in trapping and propulsion of dielectric microparticles and biological cells in the evanescent fields of optical waveguides [2-4], which may form part of a planar microsystem into which optical detection and spectroscopy of separated species could also be integrated. Optical waveguides embedded in surfaces represent a powerful means of controlling the distribution of optical intensity and intensity gradient at such surfaces, for particle control, and recent results on the manipulation of biological cells will be described.

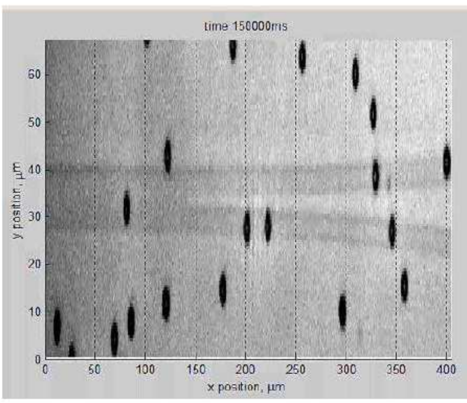

Fig 1. Waveguide particle sorting

Integrated optofluidic components

Evanescent fields supported by optical waveguides are ideal probes for surface interactions, but in applications where the volume of a liquid or of a micron-scale object such as a biological cell is to be interrogated, in-plane optofluidic approaches must be adopted [5,6]. Optical waveguide devices must be integrated with microfluidic channels to excite a defined volume in the fluid and to collect the scattered spectrum, in terms of angle or wavelength. A key example function is that of the in-plane lens, which can be used for trapping, scattering, fluorescence or Raman measurements. Kinoform lenses are promising candidates for in-plane lenses, due to their compactness and flexibility in design [7]. Advances in technologies incorporating integrated lenses for microcytometry will be described.

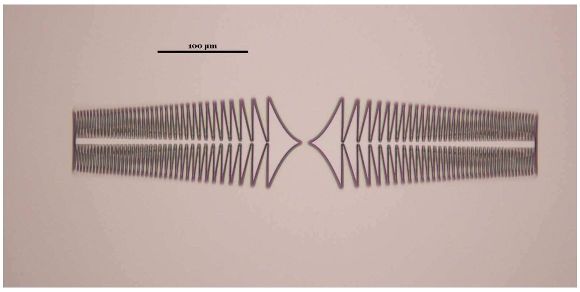

Fig 2. Integrated kinoform lens

Conclusions

The lab-on-a-chip presents great benefits in terms of reagent and sample consumption, speed, precision, and automation of analysis, and thus cost and ease of use, resulting in growing adoption of microfluidic approaches for practical measurements, and the potential for their widespread use in society. Optical techniques are ubiquitous in bio/chemical analysis and in the manipulation of biological cells, and optical waveguide devices show promise for on-chip integration with microfluidic systems for ultra-high performance, if low-cost approaches to fabrication and deployment can be achieved.

References

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