Optical traps for analysis of living cells by Raman spectroscopy

S. Dochow[1], C. Krafft[1], J. Popp[1,2]

1. Institute of Photonic Technology, Jena, Germany
2. Institute of Physical Chemistry, University Jena, Jena, Germany

Within the research initiative "Jena Cell Identification Group" (Jenzig) optical micromanipulation tools are developed to identify single cells. This work includes microfluidics, optical traps and optical spectroscopy for detection. For characterization of single cells Raman spectroscopy provides a sensitive fingerprint on the chemical and molecular composition. The advantage of this method is that it is label free, non destructive and highly specific. Due to the low efficiency of the linear Raman process, exposure times of several seconds or more are usually needed to obtain a Raman spectrum of sufficient signal to noise ratio. To collect Raman spectra of cells suspended in medium or moving in flow devices they have to be physically fixed in the laser focus during data accumulation. Optical tweezers and optical traps were recently compared with respect to their application for Raman spectroscopy of cells[1], [2]. The use of two divergent lasers in optical traps reduces the risk of radiation damages[3]. Furthermore, optical traps enable to stretch cells and determine their elasticity.[4] Using optical traps metastatic tumor cells were shown to be more elastic than non-metastatic cells [5].

The presentation will compare optical traps and microfluidic devices that have been realized. Yeast cells were used as model systems to demonstrate the functionality of both systems. The following properties have been considered so far:

- 785 nm laser excitation has been reported not to induce irreversible damages to living cells. If optical traps operate with fiber laser emitting at 1070 nm and Raman spectra are excited at 785 nm, spectral data can be registered up to 3400 relative wavenumbers. Higher wavenumbers overlap with the trapping lasers. Optical filters have to be integrated to suppress the scattered radiation of the trapping lasers.
- Most microfluidic chips are made of materials such as PMMA or glass which are not compatible with Raman spectroscopy using 785 nm excitation lasers. Fused silica or quartz show less background signals. However, processing procedures have to be adapted for these materials.
- The bonding process of glass wafers includes a bonding layer. This layer absorbs much of the trapping radiation and deforms the beam profile that new materials (e.g. quartz glass or fused silica) and processes (diffusion bonding [6]) have to be developed.
- A cell trapping setup was constructed using squared quartz capillaries and glass type chips.
- A Labview based interface was developed to control the intensity of the trapping lasers and allows shifting trapped particles inside a micro fluidic channel. Further functions will be included.
- The recent trapping experiments show that yeast cells are not the optimal demonstration cell because of their refractive index which is near to that of water. New demonstration cells need to be found.

References:

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