Photothermal heterodyne imaging in air and aqueous media – parameters and perspectives

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Introduction

First described by Berciaud et al. [2] [3] for imaging of metallic and crystal nanoparticles, the photothermal (PT) heterodyne technique combines biological specificity and sub-micron resolution. Albeit it has been explored in a myriad of applications [1], data on imaging in water are rather scarce.

A dedicated PT testbed was implemented at TU Wien. System parameters were carefully modified to better understand the mechanisms governing PT image quality. Design choices and parameters for PT imaging will be explained and supported by theoretical evidence.

Methods

The presented testbed is based on an existing confocal microscope at TU Wien. Simulations were carried out to optimise the setup for broadband IR laser sources and a transmission geometry. The confocal microscope was modified to incorporate a second objective for bottom illumination with an IR laser (pump laser). The samples were probed with a HeNe laser (633 nm), and the transmitted PT signal was collected by an off-the-shelf amplified photodiode and recovered from the modulation of the visible beam using a lock-in amplifier. PT spectra and images of polystyrene beads of various sizes were recorded in both air and water. The imaging parameters and observed artifacts were checked for consistency with theoretical expectations.

Results

PT imaging of 1 µm beads has revealed an optical resolution of 1.5 µm, which is well below the diffraction limit of the 6 µm IR beam. The calculated signal-to-noise ratio (SNR) ranged from 5 to almost 80 depending on the parameters and the environment of the experiment.

The SNR critically depends on the choice of imaging parameters, which can be found by theoretical considerations. The presence of fringes in PT imaging has been attributed to the object of interest being off-centre of the confocal laser spot.

Measurements in water have been demonstrated but remain challenging. Further optimisation will be required to improve SNR and avoid damage to sensitive samples.

Innovative aspects

- Innovative setup based on existing confocal instrument
- Theoretical background of imaging parameters and artifacts
- Photothermal imaging in water

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