Optically trapped microsensors for microfluidic temperature measurement by fluorescence lifetime imaging microscopy

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Supplementary Information

Multiparameter Microscope

The multiparameter microscope was designed to provide a platform with the potential of implementing two independent tweezer channels, the ability to switch between two or more excitation sources, and to accommodate two or more detector / camera channels. The microscope setup is relatively easy to align and reconfigure by someone with basic or limited experience in the alignment of optical systems, and the key components are easily accessed.

The design is based on a slotted baseplate is depicted in Fig. S1. A designed network of fixed width slots is accurately machined into the surface of a plate of aluminium. The optical components or devices are mounted in cylindrical barrels and placed in the slot as shown. The barrels are held in place using either a magnet or clamp. A barrel placed in the slot has four of the six degrees of freedom constrained. This semi-kinematic mount allows accurate adjustment of the two remaining degrees of freedom: translation of the component along the optic axis of the slot (focus) and rotation of the component about the axis.

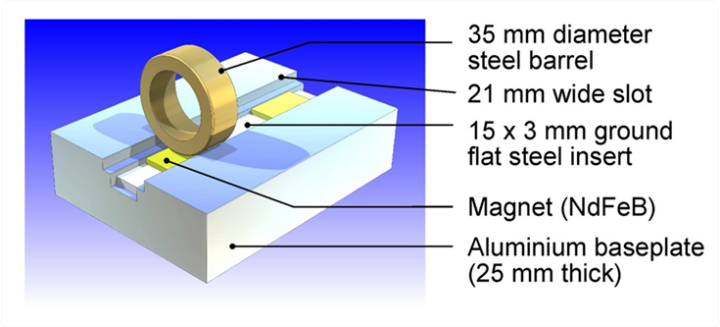

Fig. S1. CAD image showing the basic construction and components used in the slotted baseplate configuration.

The footprint of the baseplate is 600 x 450 mm – this was largely determined by the space required for the telescoping of the laser beam for the tweezers, the magnifications needed in the detector channels, and the optical layout required for the routing of the excitation beams. The layout of optical components on the baseplate is shown in Fig. S2. A combination of custom-made and off-the-shelf optomechanical components was used.

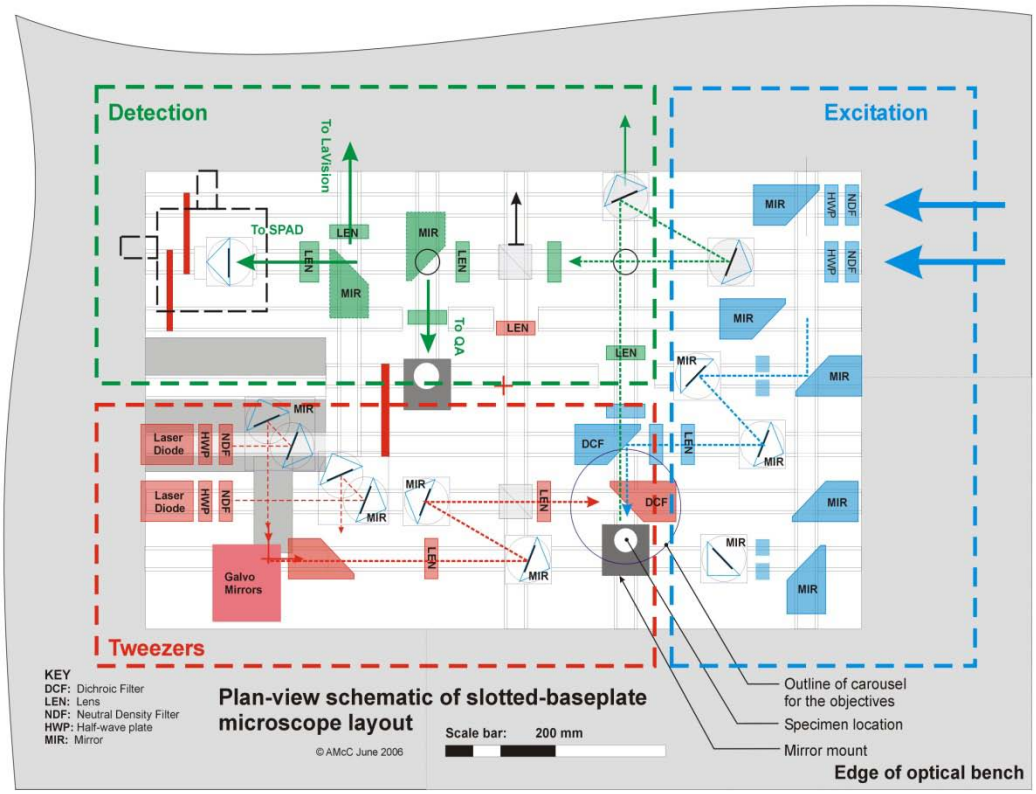

Fig. S2. Overall layout of the multiparameter microscope.

Fluorescence Decay Curves

Fluorescence decay data used to construct the temperature versus lifetime calibration curve are shown in Figures S3 to S6. In order to construct the calibration curve to apply to the FLIM data it is necessary to fit the decays acquired by TCSPC over the same time range as that used when fitting the data recorded using the FLIM system, from 1ns after the decay peak to 8ns after the decay peak. The single exponential function fitted over this truncated range is shown in each case, together with the residuals.

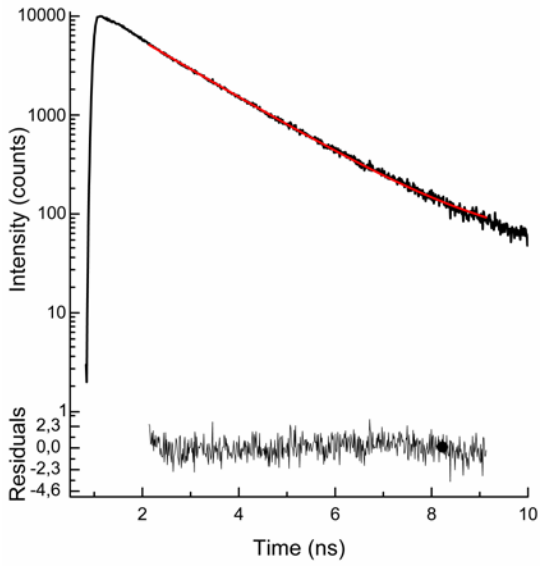

Fig. S3. Fluorescence decay of the microemulsion at 27 °C (black) together with the fitted monoexponential function (red). The weighted residuals are also shown. The lifetime, τ_s, derived from the fit is 1.51 ns and the value of the χ^2 parameter is 1.00.

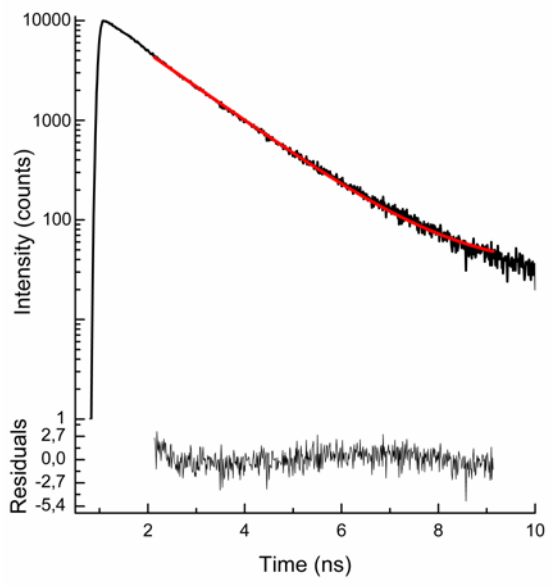

Fig. S4. Fluorescence decay of the microemulsion at 35.2 °C (black) together with the fitted monoexponential function (red). The weighted residuals are also shown. The lifetime, τ_s, derived from the fit is 1.26 ns and the value of the χ^2 parameter is 1.19.

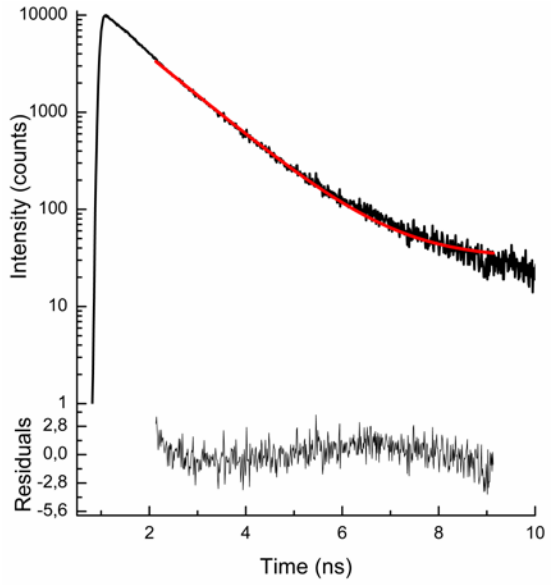

Fig. S5. Fluorescence decay of the microemulsion at 44 °C (black) together with the fitted monoexponential function (red). The weighted residuals are also shown. The lifetime, τ_s, derived from the fit is 1.06 ns and the value of the χ^2 parameter is 1.56.

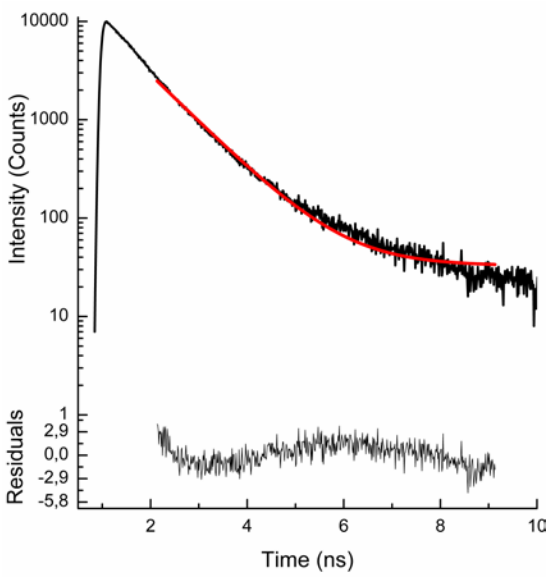

Fig. S6. Fluorescence decay of the microemulsion at 61.4 °C (black) together with the fitted monoexponential function (red). The weighted residuals are also shown. The lifetime, τ_s, derived from the fit is 0.79 ns and the value of the χ^2 parameter is 2.1.

Positions of trapped microdroplets

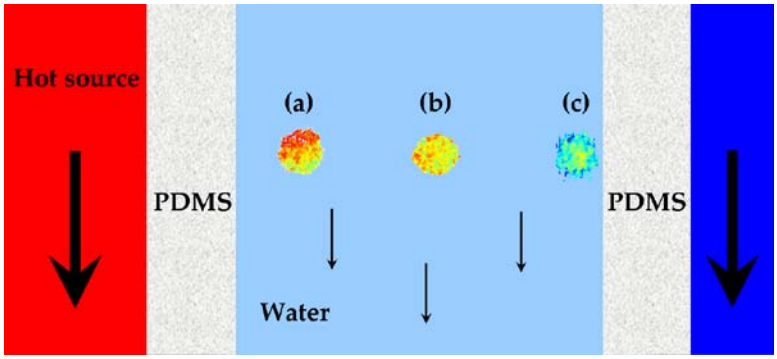

Fig. S7. Positions of the trapped microdroplets shown on the FLIM image in Fig. 7 of the manuscript.