8CB liquid crystal as fast calibration media for micro-thermal device

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1 Introduction

Micro-devices provide an interesting platform for experiments consisting in monitoring the temperature response of biological species. A temperature sensor integrated on a micro-device for such experiments requires affordable, rapid and accurate thermal calibration. However, no method of thermal calibration directly under the microscope has been reported so far. This is currently the main limitation in many experiments with micro thermal devices. We here present an inexpensive, fast and accurate way to achieve such thermal calibration directly under the microscope.

We designed and manufactured a micro-device with thermal capabilities for biological applications on a quartz wafer [1]. This device consists in two main elements: a heater and a temperature sensor. The heater is a 2μm wide platinum wire, while the sensor is a Platinum / Chromium thin film thermocouple, TFTC, with a $2.5\text{x}2.5\mu m^2$ hot junction (Fig 1(a)). We then used the thermotropic liquid crystal 4-n-octyl-4-cyanobiphenyl (8CB) in order to reach the 313 K isothermal phase change on the device. Coupled with FEA simulations (Fig 1(b) & (c) & Tab. 1), we proved that this method enables us to make easy and accurate thermal calibration of micro-thermal device for biological application.

2 Calibration setup and methodology

Liquid crystals mixed with $\Phi = 1\mu m$ beads were poured onto the microthermal device and a glass slide was placed on top of the droplet so as to facilitate observation and delay evaporation. This also approximates the experimental conditions used in our laboratory with biological species.

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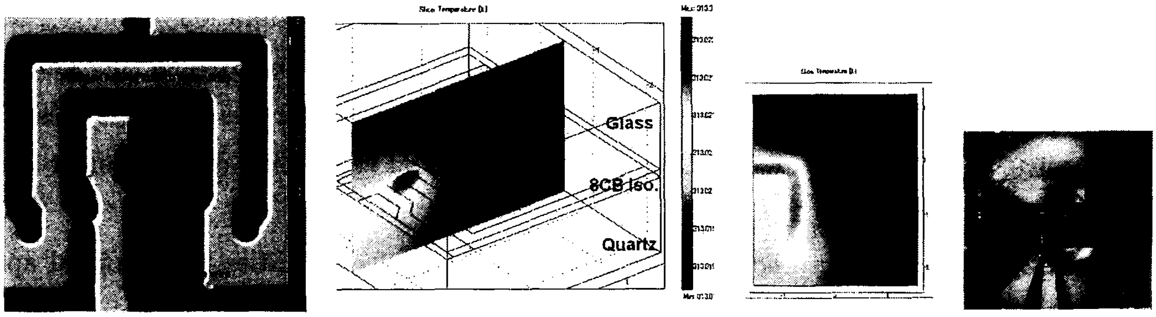
We used a 20X objective (CF Plan, Nikon) for observation under both brightfield conditions (reflected light) and polarized (transmitted) light.

We observed in real time Nematic - Isotropic phase transition of 8CB, which occurs at 313 K. The N-I transition has been recognized to be pure first order transition [2]. One may thus guarantee that the thermal sensor output recorded when the phase transition is located right over it corresponds to a measured temperature of 313 K (Fig 1(d)). Room temperature corresponds to null output. Considering the Pt-Cr TFTC linear behavior within 275 K - 375 K range, we can then obtain the thermocouple calibration curve.

Material	ρ, $kg.m^{-3}$	C_p, $J.(kg.K)^{-1}$	λ, $W.(m.K)^{-1}$
Pt	21450	133	71.6
Cr	2203	703	1.38
8CB Iso.	870	2200	1.55

Table 1: Material thermal characteristics used for simulations.



(a) (b) (c) (d)

Figure 1: (a) SEM view of the device, temperature distribution in (b) a vertical plan containing a section of the heater and the TFTC hot junction, and (c) an horizontal plan in the 8CB at 0.5μm above the quartz surface, (d) observation under polarized light when applying 1.2V at the heater. 8CB Iso. phase appears in dark above the TFTC.

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References

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