Real-time monitoring of the nematic-isotropic phase transition in liquid crystal films

This application note illustrates how Insplorion's Nanoplasmonic Sensing (NPS) technique can be used in real-time to monitor the first order phase transition from nematic to isotropic phase in liquid crystal films.

Introduction

Liquid crystals (LCs) have a wide applicability, from LCDs to organic solar cells. Here, a novel, simplistic, method for determining the phase transition temperature is described. At low temperatures the LCs are dominated by crystalline properties with the material showing some degree of translational order (Figure 1). As the temperature increases, the material properties are more similar to those of a liquid. The phase transition, T_c, temperature at which the material properties change is an important characteristic of the LC. To demonstrate how NPS can be used to study the transition, we have used the common calamitic nematogen 5CB (4-Cyano-4'-pentylbiphenyl) as a model system. This particular liquid crystal undergoes a phase transition from nematic to isotropic phase at 35 °C.

Experimental Procedure

Standard Insplorion NPS sensors with Si_3N_4 coating were cleaned with UV/Ozone in air for 15 minutes. After which, the liquid crystals were spin coated onto the substrate. The crystals were dissolved in toluene at 8%

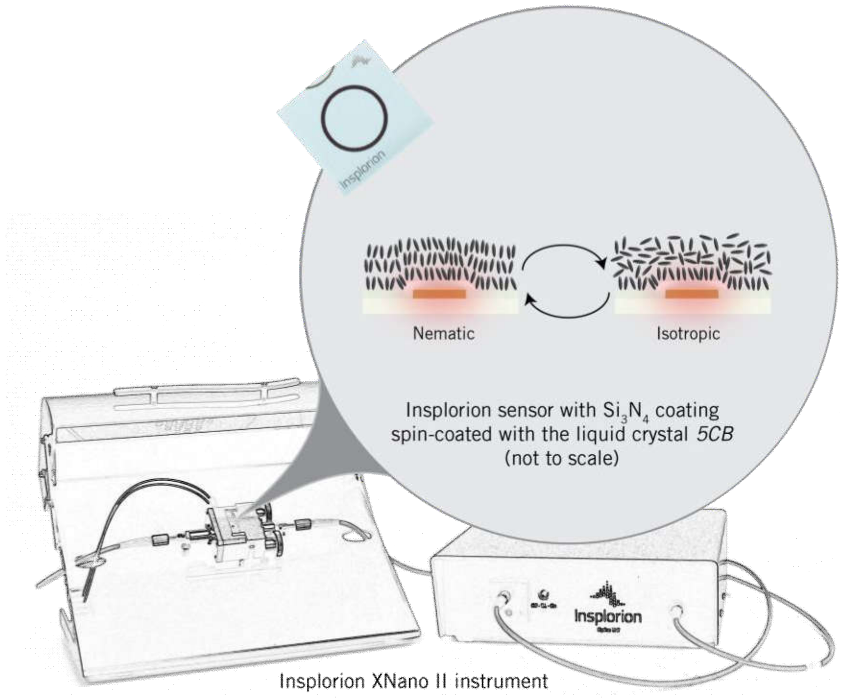

Figure 1: Insplorion system setup. The inset shows a schematic illustration of the sensors and molecules used in this application example (not to scale!).

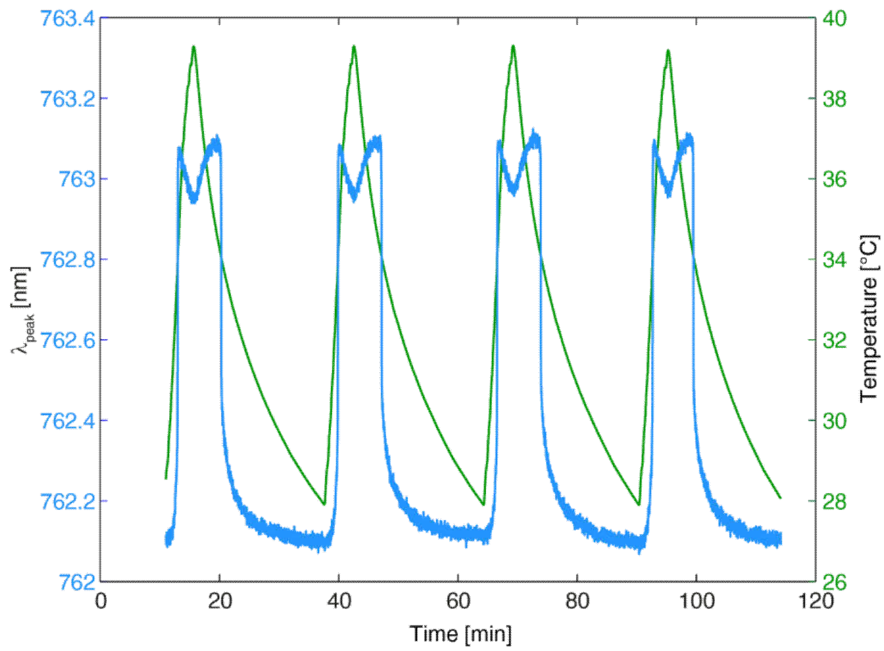

Figure 2. NPS signal and temperature as a function of time,. –At the phase transition temperature, there is a drastic shift in NPS signal, obvious during both heating and cooling.

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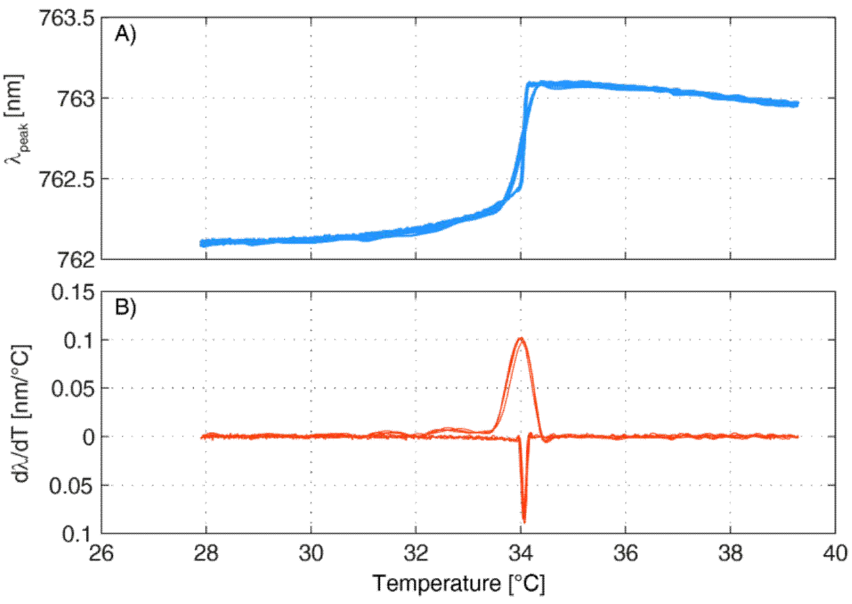

Figure 3. A) The NPS signal as a function of temperature. The graph show four superimposed temperature cycles. B) Time derivative of the data in A. The phase transition temperature is clearly seen in both graphs.

v/v. After spin-coating, the sensors were covered with a glass slide, enabling anchoring at both interfaces. The structuring effect from the glass/sensor surfaces at the interface induces some molecular organisation in the surface layers of the film. This perturbation of the mesophase is, however, only expected to reach a few molecular lengths into the film, hence yielding a negligible change in the transition temperature. The sample was then loaded into the Xnano II measurement chamber and the temperature was scanned over the interval 28 - 40 °C.

Results

The shift in the plasmonic peak position (λ_{peak}) was monitored in real-time while cycling the temperature (Figure 2). The data from four consecutive temperature cycles are shown superimposed in Figure 3A. The transition temperature is determined by finding the extremes of the time derivative of the NPS signal (Figure 3B). This yields clear peaks located at around 34 °C. A small hysteresis between the transition temperatures during heating and cooling is seen (0.1 °C).

Conclusions

The Insplorion Xnano II system is well suited for studying phase transitions in for example liquid crystals. The transition temperature is easily found by analyzing the time derivative of the NPS signal. The results can be generalised to other similar systems, such as gel transition in lipid bilayers.

All work and experiments were performed in house by Insplorion AB.

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