

***In-situ* optical characterisation of the spatial dynamics of liquid crystalline nanocomposites**

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Liquid crystalline nanocomposites are a novel class of hybrid fluid materials, which are currently attracting significant interest from the photonics community. Such fluid nano-composites are based on low-dimensional nanoparticles (carbon nanotubes, graphene, transition metal dichalcogenides (TMDCs), metal nanoparticles etc.) dispersed in a fluidic host material. Liquid crystalline properties can either be provided by using a liquid crystal host fluid, or, through the solvent-induced self-assembly of particles. They possess a unique capability to interact with light, utilising many possibilities in plasmonics and quantum optics while they can also be integrated on Si chip by means of microfluidic technology. Integration of the nanocomposites on chip allows for dynamic control of the dispersed particle ordering through the application of various external stimuli. However, this dynamic control requires a suitable characterisation technique to fully understand the time evolution of metastructure formation. Integrated nanocomposites are characterised by the particle concentration at different points on chip, while the individual particles are defined by their sizes, xyz positions and orientation relative to the chip architecture. Here, we present a method by which all the required information for complete characterisation of the system can be obtained using a single spectroscopic technique- Raman spectroscopy- and how changes in the system can then be monitored during device operation. Liquid crystalline nanocomposites have been synthesised based on two-dimensional (2D) materials including graphene oxide (GO) and TMDCs dispersed in either commercially available liquid crystals or various organic solvents. We present both numerical analysis of the theoretical practicability of the use of Raman spectroscopy to extrapolate the desired nanocomposite properties and the experimental confirmation of the achievability of these measurements for the full range of synthesised nanocomposites.