

methodology that may also be applicable to other biomaterials.

This study is motivated in part by the recent discovery of liquid crystal phases of ultra-short duplex nano-DNA and RNA oligomers [7]. Nano-length DNA oligomers, with base pair number in the range $6 < n < 20$ have been found to exhibit both nematic (N) and uniaxial columnar (C_U) phases in aqueous solution. Such short self-complementary oligomers form double-helical duplex aggregates at room temperature which, by virtue of their hydrophobic ends, further self-assemble end-to-end to form rod-shaped super-aggregates that can LC order. Both a nematic phase and a uniaxial columnar phase are found, in which



Figure 2. Sample preparation of duplex hydrated nano-DNA columnar LC phase in the confined micro-channels and optical images obtained by depolarised reflected light microscopy (DRLM). (a) LC is filled in the silicon channels with $5\ \mu\text{m}$ depth and $3\ \mu\text{m}$ width (or $10\ \mu\text{m}$ width for the dehydrated sample of Figure 4), and the x-, y- and z-directions are defined. LD is the loading direction of the LC sample. (b–e) Optical images of the confined DNA phase in the confined area $\varphi = 90^\circ$, 45° , 30° and 0° rotated sample respectively. Clear alternation of brightness is observed upon rotating the sample, giving information about the molecular orientation in the channel; the two parallel white bars in image (e) indicate channel direction 'y'.

(Figure 2(c)) and the path length is 2 for observation in reflection. We can consider two basic orientations of the C_U phase: with n normal to the plates there is no in-plane birefringence and the image is dark (see Figure S4 in reference [7]); with n parallel to the cell plates, the uniaxial birefringence $\Delta n = n_{\parallel} - n_{\perp}$, where n_{\parallel} is the refractive index for light polarised parallel to n and n_{\perp} is the refractive index for light polarised normal to n , produces a relative phase shift of these modes. The $\sin^2 2\varphi$ term in gives minimum reflectance for $\varphi = 0^\circ, 90^\circ, 180^\circ$



Figure 3. FCPM images of aligned duplex hydrated nano-DNA LC in $= 3 \mu\text{m}$ wide Si channels. (a) 0° polarisation (parallel

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