Liquid Crystal Alignment by Nano-scale Surface Patterning

Conventional methods for liquid crystal (LC) alignment usually employ *uniform* surface conditioning for the anchoring substrate of the LC. But in this approach, we use *inhomogeneous* substrate patterning to achieve the alignment effect. The substrate patterns consist of domains of alternating horizontal and vertical grooves (Fig. 1).

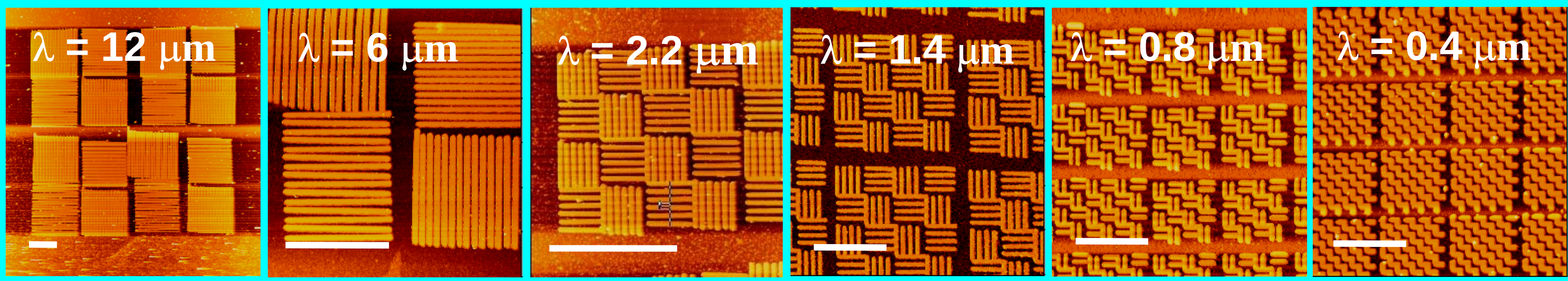

Fig. 1 Atomic force microscopic (AFM) topographical images of the nano surface patterns used in this study for the control of LC alignment. The patterns were fabricated by the AFM local oxidation method [1]. The scale bars represent 3 μm.

The principle of LC alignment in here is due to a frustrated boundary condition in which the LC director, in coping with the spatially varying groove orientation, may build up a large enough elastic energy that can overwhelm the local surface anchoring energy of individual domains, resulting in a globally uniform LC configuration. In an experiment realizing this idea (Fig. 2), we

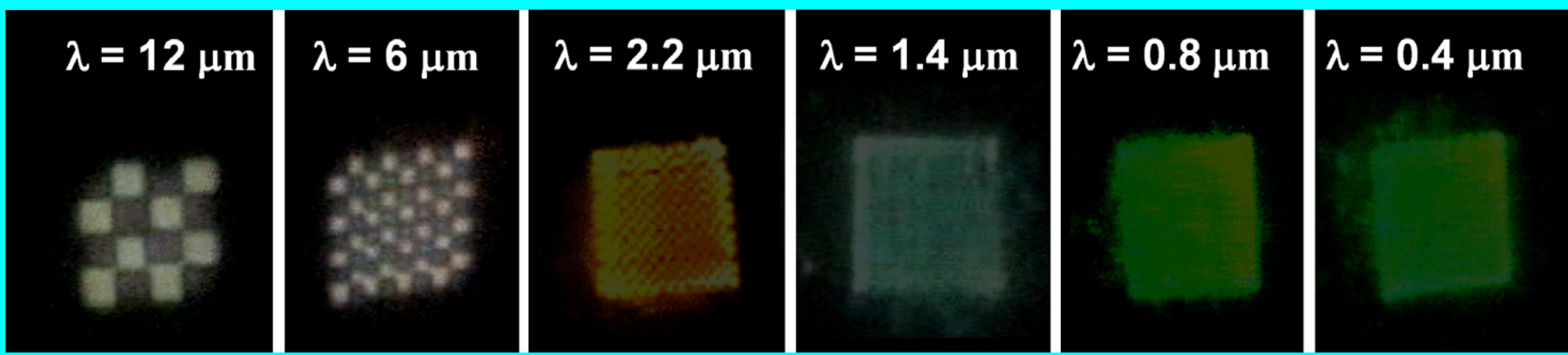

Fig. 2 Optical images of LC cells constructed with one side made of the substrates illustrated in Fig. 1 and the other side ITO/glass coated with polyimide rubbed along ***y***. The images were taken with the LC cells placed between crossed polarizers with the entrance polarizer oriented along ***y***. An inhomogeneous-to-uniform LC alignment transition near λ = 0.8 μm is readily apparent from these images. Please refer to Ref. 2 for more details.

found the LC orientation transition to be far more novel than was originally contemplated. We found the uniform state possessed an unexpectedly large pre-tilt angle (~40^{o}). With the aid of a model basing on the frustrated boundary condition, we recognized that the orientation transition actually comprises two steps. First the LC director homogenizes towards the 45^{o} azimuthal direction to relax the elastic energy (Fig. 3). The resulting rise in azimuthal anchoring energy then pushes the LC director away

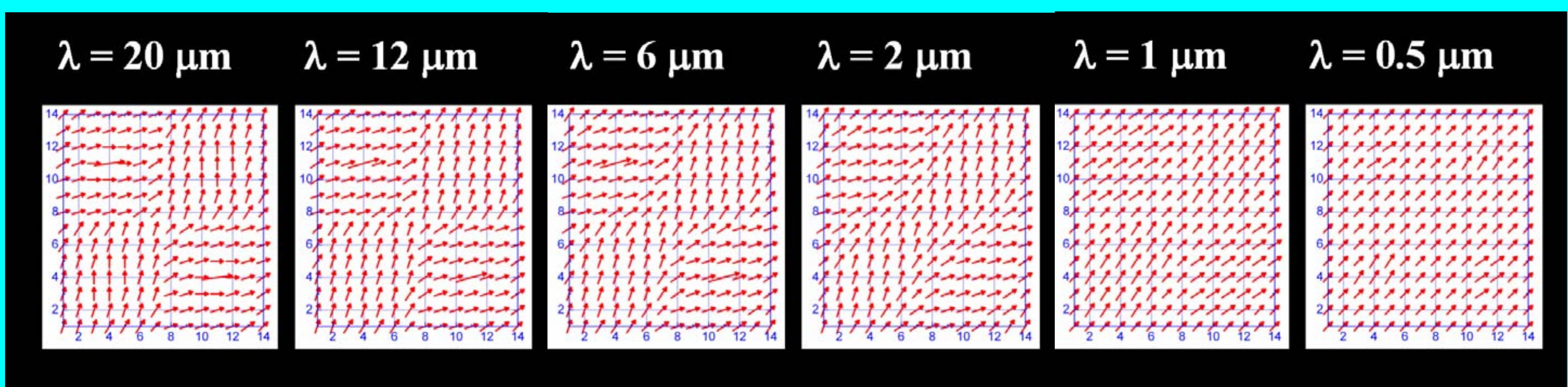

Fig. 3 In-plane configurations of the LC director near the patterned substrate surface obtained by model simulations. For details, please refer to Ref. 3.

from the substrate to adopt a large pre-tilt angle. The model also reveals that the LC orientation in the uniform state is adjustable by varying the azimuthal and polar anchoring energy of the local microdomains as well as the elastic constants of the LC, all of which are easily tunable parameters. This result thus signifies the possibility to control LC alignment by inhomogeneous substrate patterning.

Publications

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