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Planar alignment of liquid crystal molecules along self-assembled GaAs quantum dashes

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Dynamically-reconfigurable photonic devices such as spectrally-tunable VCSELs sources (vertical-cavity surface-emitting lasers) or spectrally-tunable photodiodes are of major interest for many applications in optical instrumentation, such as compact gas sensing or biomedical imaging. The most mature way for producing a tunable VCSEL is based on the insertion of a MEMS (moving electromechanical system) inside or above the III-V semiconductor active device. However, this approach presents several limitations due to mechanical vibrations. Exploiting instead birefringence effects in a liquid crystal (LC) intracavity layer is a promising solution, as it would enable better wavelength control and stability.

However, LC-based tunable laser diode technology is still in its infancy due to the complexity of aligning liquid crystal molecules inside a III-V semiconductor optoelectronic device. To address this issue, the authors previously developed a polymer-based LC microcell (μ -cell) technology including a sub-wavelength period grating nano-imprinted in a SU-8 resist for LC alignment [1] (figure 1). A high finesse tunable optical filter, as well as a tunable photodiode [2] and an optically-pumped tunable VCSEL [3] could be demonstrated using this hybrid method. To further improve tuning performances and reduce the complexity of the technology, we demonstrate in this work that liquid crystal molecules can be directly aligned by GaAs anisotropic self-assembled nanocrystals, suppressing thus the need for inserting and patterning an organic alignment layer. The optimized conditions for the epitaxial growth and *in situ* annealing of self-assembled GaAs quantum dashes (QDHs) suitable for LC alignment (figure 2) are presented, as well as the process developed for the fabrication of a hybrid LC- μ cell including such elongated nanostructures. We show that LC alignment based on QDHs is as efficient as that obtained along the grooves of the SU-8 nanograting and what is more, with lower electrical consumption.

- [1] Sadani, B., Boisnard, B., Lafosse, X., Camps, T., Doucet, J. B., Daran, E., ... & Bardinal, V. (2018). Liquid-crystal alignment by a nanoimprinted grating for wafer-scale fabrication of tunable devices. *IEEE Photonics Technology Letters*, 30(15), 1388-1391.
- [2] Levallois, C., Sadani, B., Boisnard, B., Camps, T., Paranthoen, C., Pes, S., ... & Bardinal, V. (2018). Liquid crystal-based tunable photodetector operating in the telecom C-band. *Optics Express*, 26(20), 25952-25961.
- [3] B. Boisnard, C. Levallois, C. Paranthoen, S. Pes, T. Camps, B. Sadani, K. Tavernier, S. Bouchoule, L. Dupont, M. Alouini, P. Debernardi, and V. Bardinal, CW operation of a tunable 1550 nm VCSEL integrating liquid-crystal microcells, *IEEE Photonics Technology Letters*, vol. 32, no. 7, pp. 391 – 394, 2020 – 4.
- [4] C. Paranthoen et al., 33 nm wavelength tuning of a 1550 nm VCSEL in CW operation based on the liquid crystal micro-cells technology, 2021 27th International Semiconductor Laser Conference (ISLC), Potsdam, Germany, 2021, pp. 1-2, doi: 0.1109/ISLC51662.2021.9615666.

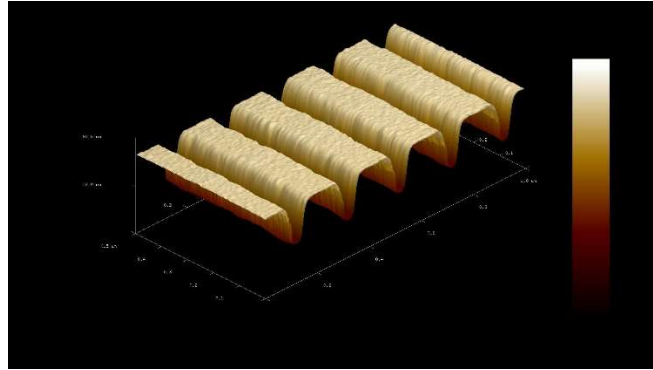


Figure 1. AFM image of the nanograting (height: 48 nm/period 200 nm) used as a reference. This grating is fabricated by soft nano-imprint in a SU-8 resist layer and already proven for planar alignment of nematic liquid crystal molecules in a microcell (image area: $0.5 \times 1 \mu\text{m}^2$).

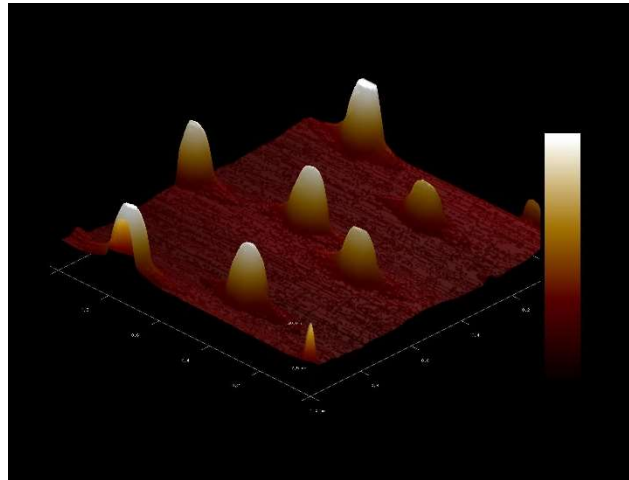


Figure 2. AFM image of the self-assembled anisotropic GaAs quantum dashes (QDHs) (average height: 21 nm, density: $\sim 8 \text{ QDHs}/\mu\text{m}^2$) fabricated by droplet epitaxy to demonstrate the feasibility of direct alignment of LC molecules in a microcell on a GaAs substrate: (image area: $1 \times 1 \mu\text{m}^2$).