# Paper No S5.3: Importance of Alignment Layers in Blue Phase Liquid Crystal Devices

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## Abstract

*In this article, we present how alignment layers affect blue phase liquid crystals and how we can use this effect to our advantage.*

## 1. Introduction

Blue phases (BPs) are helical phases existing between isotropic and chiral nematic phases, in highly chiral liquid crystals. There are three types of BPs, BPI, BPII, and BPII, in the order of increasing temperatures of their existence. The building blocks of BPs are double twisted cylinders (DTCs) and the disclination lines. In BPI and BPII, DTCs are arranged in such a way that cubic arrangement of defects in the director fields is formed, making BPI body-centered cubic (bcc) and BPII simple cubic (sc) [1]. In BPII, DCTs are randomly distributed resulting in amorphous phase. Owing to the fundamental difference in their internal structures, BPI and BPII differ significantly in various aspects [2].

In recent years, blue phase liquid crystals (BPLCs) have emerged as the candidate material of future display and other advanced photonic components. Fast switching speeds [3], optically isotropic off state, insensitivity toward cell gap, and considerable ease of fabrication resulting from the nonrequirement of alignment layers are some of the outstanding features of this phase.

It was recently reported by Kikuchi et al. that the Kerr constant is not a scalar, but a tensor quantity as is true for various other physical properties in cubic crystals. By carefully controlling the orientation of domains, 20% increment in Kerr constant was demonstrated [4], which directly implies lowering of the operating voltage.

## 2. Results

The LC mixture used in this study has the following composition: nematic liquid crystals JC1041-xx (48.18%) and 5CB (38.08%), chiral dopant (3.2%), monomer EHA (3.43%), crosslinker RM257 (6.66%), and photoinitiator DMPAP (0.52%, from Merck). The polarization optical micrographs of BP in LC cells with and without alignment layers are shown in Figure 1. Both the samples are at 44.6°C. Considerable difference can clearly be seen. BP in the cell without alignment layers (Figure 1(b)) has randomly oriented domains reflecting in the deep blue wavelength range, whereas in the cell with alignment layers (Figure 1(a)), a uniform texture is present.

Further investigation by means of tracking changes in the peak Bragg reflection wavelength at various temperatures, it was found that the alignment layers have tremendous influence on the orientation of domains of BPLCs. Also, the magnitude of influence differs in the two types of cubic BPs. In BPII, smaller domains with assistance from the alignment layers merge forming larger domains and also experience reorientation which leads to shift in peak Bragg reflection wavelength. A shift form 338.5 to 486.3 nm was recorded.

Samples were also successfully polymer stabilized in various states of orientation.

## 3. Conclusions

Contrary to the prevailing perception, alignment layers can be of crucial importance in exercising control over the orientation of cubic domains of BPLCs and hence improving electro-optical properties of the same.

## 4. Acknowledgements

This work is partly supported by the Research Foundation-Flanders through the project 3GA04711 ("Study of liquid crystals dispersed in micro-structured elastic host materials") and partly by the IWT through the SBO project SECONDOS, IWT-nr 120019, 2013-2016.

## 5. References

[1] D. C. Wright, N. D. Mermin, "Crystalline liquids: The blue phases", Rev. Mod. Phys., Vol. **61**, p. 385, 1989.

[2] H. Choi, H. Higuchi, H. Kikuchi, "Fast electro-optic switching in liquid crystal blue phase II", Appl. Phys. Lett., Vol. **98**, p. 131905, 2011.

[3] Y. Chen, D. Xu, S.-T. Wu, S.-I. Yamamoto, Y. Haseba, "A low voltage and submillisecond-response polymer-stabilized blue phase liquid crystal", Appl. Phys. Lett., Vol. **102**, p. 141116, 2013.

[4] Y. Kawata, H. Yoshida, S. Tanaka, A. Konkanok, M. Ozaki, H. Kikuchi, "Anisotropy of the electro-optic Kerr effect in polymer-stabilized blue phases", Phys. Rev. E, Vol. **91**, p. 022503, 2015.

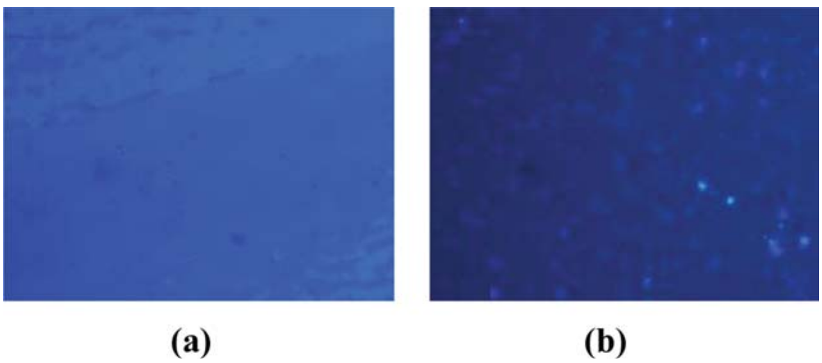


**Figure 1. POM of BPLC (a) with and (b) without alignment layers at 44.6°C.**

 