Alignment Control of Nanostructures in Liquid-Crystalline Block Copolymers by Scanning Wave Photopolymerization

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Nanostructures have been widely utilized in diverse fields ranging from electronic devices to energy and environmental applications, owing to their small feature sizes and large specific surface areas. Block copolymers are promising self-assembling materials for forming well-defined nanostructures [1]. They spontaneously form periodic nanostructures through microphase separation, and their morphology and functionality can be tailored through molecular design (Figure 1). Alignment control of these nanostructures is essential for fully exploiting their functionality. However, conventional alignment methods are generally performed after polymerization, where the low mobility of polymer chains limits controllability.

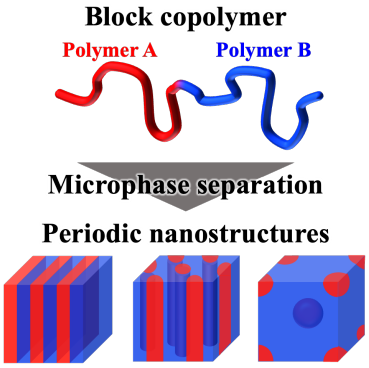

Figure 1. Microphase separation of block copolymers.

Recently, we developed a new molecular alignment method, termed scanning wave photopolymerization (SWaP) [2]. SWaP induces molecular alignment during photopolymerization by spatially selective light irradiation (Figure 2). We hypothesized that SWaP would enable alignment control of nanostructures in block copolymers during the polymerization process, when the system retains high mobility. Here, we synthesized liquid-crystalline block copolymers by SWaP and investigated their molecular and nanostructural alignment. We revealed that aligned nanostructures were directly formed in a single step by SWaP. Furthermore, by designing the light-irradiation patterns, we achieved various two-dimensional alignment patterns.

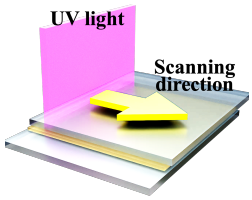

Figure 2. Schematic illustration of SWaP.

References

[1] G. Y. Geon, O. K. Sang, *et al.*, "Block copolymer nanopatterning for nonsemiconductor device applications", ACS Appl. Mater. Interfaces **14**, 12011–12037, 2022.
[2] K. Hisano, A. Shishido, *et al.*, "Scanning wave photopolymerization enables dye-free alignment patterning of liquid crystals", Sci. Adv. **3**, e1701610, 2017.