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Patterned alignment layers by capillary force lithography for multi-domain liquid crystal structures

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We demonstrate the use of capillary force lithography (CFL) method to align a liquid crystal (LC) in patterned azimuthal orientations. The ability to pattern a LC alignment layer is of importance for LC applications such as wide-viewing LC displays, optical communication devices, and several types of diffractive optical elements to improve electrooptic (EO) properties and give an additional functionality. Recently, several approaches to pattern a LC alignment surface have been proposed, which includes a selective rubbing method with photolithographic protecting layers, a photoalignment with masks, holographic methods, a dip pen nanolithography using an atomic force microscope tip, and a micro-rubbing method with a metallic sphere. However, conventional multi-domain alignment methods require complex procedures, which is not suitable for large are patterning. In this work, we produced multi-directional easy axis on the LC-aligning surface using selective dewetting process of isotatic polystyrene (PS) film on a polyimide (PI) layer. When the PS layer, coated on the PI layer, was contacted on the patterned mold substrate with weak pressure and heated above the glass-transition temperature of PS (T_g=100^{o}C), pressure-assisted capillary filling of PS melt into the mold structure took place without severe degradation of the base PI layer since the thermal stability of the PI is much higher than that of the PS. After the pressure-assisted CFL process, the PS layer was patterned on the uniform PI layer in 10 μm x 10 μm sub-pixel size. When the patterned substrate was rubbed unidirectionally, the easy axes of the PS layer and the PI layer were orthogonal each other since the LCs on the PI layer are aligned along the rubbing direction, while those on the isotatic PS layer are aligned perpendicular to the rubbing direction. Our patterning method utilizing difference in the thermal stability and the rubbing-induced easy axis orientation between two polymers would be very useful for improving the performance of the LC devices via manipulation of patterned LC geometries.