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FEATURE ARTICLE

Photoalignment of liquid crystals: basics and current trends

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The review describes the status of the studies and the recent achievements in the field of photoalignment of liquid crystals. An update classification of photoaligning materials and exposure schemes, and analyzes of the relationship between the molecular structure of the materials and characteristics of LC alignment are provided. In addition, bulk mediated photoalignment and combination of photoalignment with other alignment methods are discussed. Along with traditional, recently proposed applications of the photoalignment technique are considered.

1. Introduction

The combination of long range orientational ordering and relatively free movement of anisotropic molecules in liquid crystals (LCs) makes these materials unique. This combination leads to exceptional sensitivity of LCs to electric and magnetic fields that initiated a booming growth of liquid crystals science and the development of a powerful LCD industry in the 1970s and 1980s. In such devices aligned layers of LCs are commonly used and the alignment is usually set by a rigid substrate with an anisotropic surface. Due to a long-range orientational interaction, the preferable alignment of a liquid crystal given by the surface extends into the liquid crystal bulk on a macroscopic scale. As this takes place, the orientational elasticity "smoothes out" orientational inhomogeneities that are unavoidably present at the surface. It allows one to obtain liquid "single-crystals" in cells with a thickness varying from several to hundreds of micrometres.

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The axis of preferable alignment of molecules in the LC is called a director of the LC, $\vec{d}$. Anisotropic interaction between the LC and the aligning surface determines the direction of the easy alignment axis of a LC on the aligning surface, $\vec{e}$. The director of the LC, $\vec{d}$, coincides with the direction of the easy axis $\vec{e}$, if the director is not affected by any elastic torque. The easy axis is given by azimuthal φ and zenithal θ angles (Fig. 1). The zenithal angle θ is often called a pretilt angle of the LC on the aligning surface. Depending on value of the pretilt, planar ($\theta = 0°$), homeotropic ($\theta = 90°$) and tilted ($0° < \theta < 90°$) alignments are distinguished. The strength of the alignment is characterized by anchoring energy, W, that determines the energy needed to deviate the director, $\vec{d}$, from the easy axis, $\vec{e}$, on a certain angle. One can differentiate between the anchoring energy related to deviation of the director in the azimuthal plane (azimuthal anchoring energy, W_{φ}) and the anchoring energy related to the deviation in the zenithal (polar) plane (polar anchoring energy, W_{θ}). The biggest industrial challenge is to obtain a uniform planar or tilted alignment of LCs with the required pretilt angle and anchoring energy and high alignment stability.

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