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Nano particles induced vertical alignment of liquid crystal for display devices with augmented morphological and electro-optical characteristics

Chinky [a], Pankaj Kumar [a, b, *], Vandna Sharma [a], Praveen Malik [c], K.K. Raina [d]

[a] Department of Applied Sciences, Chitkara University Institute of Engineering and Technology, Chitkara University, Patiala, 140401, Punjab, India
[b] Chitkara University Research and Innovation Network, Chitkara University, Patiala, 140401, Punjab, India
[c] Liquid Crystal Lab, Department of Physics, Dr. B. R. Ambedkar National Institute of Technology, Jalandhar, 144011, Punjab, India
[d] DIT University, Mussoorie-Diversion Road, Dehradun, 248009, Uttarakhand, India

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ABSTRACT

In this work, vertically aligned electro-optical (E-O) cells were fabricated using plane Indium–Tin-Oxide (ITO) substrates without any surface treatment of ITO for the alignment of liquid crystal (LC) molecules. Experimentally, using a specific amount (0.3% wt/wt) of Zinc oxide (ZnO) nano particles (NPs) in NPs-LC mixture, a high quality vertically aligned liquid crystal (VALC) was achieved in cells without compromising physical properties of LC. Results reveal much improved morphological and E-O characteristics of display cells by lowering the threshold voltage to 1.68 V for NPs induced VALC compared with 1.86 V for polyimide induced vertically aligned liquid crystal (PIVALC) cell. The operating voltages were observed 1.96 V and 2.2 V for NPs induced VALC and PIVALC cells, respectively. The contrast ratio (CR) was obtained ~12.4% better for NPs induced VALC cell compared with PIVALC cell. Further, isotropic temperature (T_{iso}) behavior was studied with polarized optical microscope (POM) and found in same order of value of temperature for both NPs induced VALC as well as PIVALC cells. Additionally, using UV–Visible spectroscopy study, optical band gap (E_g) was calculated and found in agreement with reported values of LC system.

1. Introduction

Liquid crystal displays (LCDs) are the most common application of liquid crystal (LC) technology and have received enormous interest of researchers due to the advantages of light weight, flatness, better contrast and low power consumption. In spite of commercialized products, such as televisions, monitors, and mobile phones, there is also great attention for the fabrication of the next-generation flexible LC displays for light weight easily carriable curved surfaces [1]. Thus, in view of fabrication, LC alignment has attracted significant interests in scientific as well as engineering aspects of LC and LCDs [2–7]. Consequently, in LCD industry, several LC methods have been developed to achieve high performance LCD distinguished by the way of LC alignment, such as twisted nematic (TN) [8,9], vertical alignment (VA) [10–12], in-plane switching (IPS) [13], and fringe field switching (FFS) [14–16] etc. Among these all, VA method is much preferable compared with the other homogeneous planar LC alignment, as vertically aligned liquid crystal (VALC) cells fabricated using the homeotropically oriented LC without an electric field, exhibit better electro-optical (E-O) performances in terms of higher contrast, wide viewing angle, fast response time, excellent image quality and unneeded mechanical rubbing process for the macroscopic LC alignment [17–19]. Generally, in VALC devices, LC molecules are vertically aligned on the substrate surface with the help of a polymer alignment layer [20]. The side-chain type polyimide polymeric materials have been most widely used as the LC alignment layers [21–26]. The schematic illustration of LC alignment at the surface of polyimide (PI) coated indium tin oxide (ITO) substrates is shown in Fig. 1(a) and depicting that LC molecule directed along normal to the surface. The normalized transmittance T/T_o of VALC cell can be illustrated with equation (1) as [27].

* Corresponding author. Department of Applied Sciences, Chitkara University Institute of Engineering and Technology, Chitkara University, Patiala, 140401, Punjab, India.
E-mail address: pankaj.kumar@chitkara.edu.in (P. Kumar).

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