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Zirconia nanoparticles/ferroelectric liquid crystal composites for ionic impurity-free memory applications†

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Achu Chandran, Jai Prakash,‡* Prasun Ganguly and Ashok M. Biradar

We observed an ionic impurity-free memory effect using a zirconia nanoparticles (ZNPs)/ferroelectric liquid crystal (FLC) composite. The pure and ZNPs doped FLC cells have been analyzed by means of dielectric spectroscopy, polarizing optical microscopy and electrical resistance/conductivity measurements. The memory behavior in ZNPs/FLC composite was confirmed by dielectric dispersion, electrical, and optical studies, whereas dielectric loss spectra confirmed the disappearance of the low-frequency relaxation peak, which appears due to the presence of ionic impurities in FLC materials. The observed memory effect has been attributed to minimization of the depolarization field and ionic charges, whereas the reduction of ionic effects has been attributed to the strong adsorption of ionic impurities on the surface of ZNPs. The ZNPs dispersed in FLCs may play a role in trapping the impurity ions (minimize the depolarization fields) under applied voltage and cause a better memory effect in ZNPs doped FLC material. Moreover, the ion adsorption capability of ZNPs is found to be almost independent of temperature as the value of resistance did not change remarkably on increasing the temperature. The reduction of ionic impurities of FLCs by doping ZNPs did not show degradation over time, as we repeated the experiments on the same sample cells after many days and did not find ionic effects in the ZNPs doped FLC materials. These studies would be helpful to provide an idea for designing ionic impurity-free memory devices.

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Introduction

Liquid crystals (LCs) have been a subject of immense research interest and practical importance because of their numerous applications, such as in flat panel displays, spatial light modulators, optical antennas, *etc.*[1–3] Among all LC materials available to date, ferroelectric LCs (FLCs), which are well known for their good optical contrast, low threshold voltage, memory effect, fast response, *etc.*, have attracted considerable attention from both fundamental and applied viewpoints.[4–7] Metal oxides play a very important role in many areas of chemistry, physics and materials science because metal elements are able to form a diverse range of oxide compounds.[8–11] These can adopt a vast number of structural geometries with electronic structures that can exhibit metallic, semiconducting or insulating characters. Metal oxides are used in various technological applications, such as microelectronic circuits, sensors, piezoelectric devices, fuel cells, coatings for the passivation of surfaces against corrosion, and as catalysts.[12–15] Metal oxide nanoparticles (NPs), interesting materials emerging from the field of nanotechnology, have attracted immense interest in the scientific community because they exhibit unique physical and chemical properties due to their limited size and a high density of corner or edge surface sites.[10,16–18]

Researchers around the world have prepared nanostructures for many oxides, but only a few of these have been systematically reported with respect to the nanostructure effect on the physical and/or chemical properties and behavior of the oxide materials. The most reported cases of metal oxide systems are Al_2O_3, MgO, ZrO_2, CeO_2, and TiO_2.[10,19] Some reported studies have also been devoted to other single oxide systems containing Zn, Fe, and Sn.[20–23] In recent years, thin films and NPs composed of zirconia material have been utilized in various devices such as electrodes, solar cells and transparent thin films because they offer many advantages including high dielectric permittivity, optical properties such as photoelectric conversion capability with the help of surface cations[24] and fluorescence emission properties under visible light,[25] excellent thermal stability and chemical inertness.[26–28] Materials scientists and technologists all around the world started to improve the dielectric and electro-optical properties of LCs by minute incorporation of metal oxide NPs. Kim and

Polymeric and Soft Materials Section, CSIR-National Physical Laboratory, Dr K. S. Krishnan Road, New Delhi-110012, India. E-mail: jpsphysics@gmail.com

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‡ Current address: Centre for Physical and Mathematical Sciences, Central University of Punjab, City Campus, Mansa Road, Bathinda-151 001, Punjab, India.