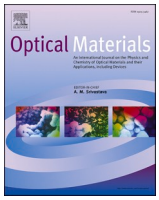
Optical Materials 148 (2024) 114837

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat



Research Article

All-nanophotonic switching in CuS_ySe_{1-y}/PMMA freestanding nanocomposite films

Hadeel N. Abd, H.L. Saadon *, Saeed J. Abbas

Laser Applications Research Group (LARG), Department of Physics, College of Science, University of Basrah, Basrah, Iraq

ARTICLE INFO

Keywords:
All-nanophotonic switching
CuS_ySe_{1-y}/PMMA nanocomposite
Nonlinear optical response

ABSTRACT

Nanophotonic switching has received increasing attention due to their ability to overcome the limitation parameters of electronic switching. For application as an all-nanophotonic switching device, a new dual-polarized pump–probe scheme based on the nonlinear optical (NLO) response of material is presented. In this scheme, two lasers-linearly polarized beams were used to pump material separately. The scheme can effectively control photonic switcher parameters with a good switching time, high modulation depth, and low switching power even if the material generates a noise, due to the scattering or speckle. In this work, ternary CuS_ySe_{1-y}/PMMA nanocomposite freestanding films were prepared in the composition range of $0 \leq y \leq 1$ at a low temperature of 80 °C using a simple chemical method. The structural, morphological, and optical properties of the ternary CuS_ySe_{1-y}/PMMA nanocomposite freestanding films were studied and characterized. Results showed that the crystallinity structure and tunable optical band gap of the ternary nanoplates CuS_ySe_{1-y}/PMMA were affected by y composition. The NLO response at wavelength of 532 nm was studied using the Z-scan technique, and the films exhibited negative refractive index n_2 and reverse saturable absorption β. Hence, all the nanocomposite films with various y compositions presented excellent figure of merits W and T, with best results obtained at y composition of 0.56. The all-optical switching effect of CuS_ySe_{1-y}/PMMA nanocomposite freestanding films at various y compositions was also demonstrated. Compared with that at 532 nm, the pump laser at wavelength of 457 nm had faster response time and can be more effective for realizing all-nanophotonic switching device. The best results were achieved at y composition of 0.56 and optimum pump power of 25 mW with maximum modulation depth of 89.7 % and switching contrast of 9.9 dB at switching time of 19 ms in the frequency modulation of 8 Hz. The prepared all-nanophotonic switching device based on ternary CuS_ySe_{1-y}/PMMA nanocomposite freestanding films provides a promising research direction and has potential application in photonic processing.

1. Introduction

Nanophotonics, the nanoscale application of photonics, has become a new research hotspot to explore light-material interactions for new application and technologies that contribute functionalities to photonic devices [1–5]. Information technology in the future relies on the research of nanophotonic switching devices, including optical communication/photonic processing that uses an optical switch, one of the most important elements of integrated photonics with low power and high speed [6–8]. The all-optical switch device features a modulation of signal light (probe) under control light (pump) to achieve the function of ON/OFF conversion. However, light can be confined in the nanoregion by using a nonlinear optical (NLO) material, an important part of the nanostructure whose optical properties change depending on the power of the pump beam [9–11].

Different schemes based on various optical materials, including inorganic crystals and organic compounds, have been proposed for all-optical switching [3,4,12]. However, some materials cannot achieve the requirements of photonic devices due to their different optical parameters. New or modified structures of materials with proper concentration are significant in developing the potential of nanoscale devices for application in photonic devices to overcome the difficulties in realizing an all-optical switch with good information processing. In this study, a new dual-polarized pump–probe scheme based on NLO response and linear polarization plane is presented to realize all-nanophotonic switching via dual control beam. The probe beam uses a NLO material

* Corresponding author.
E-mail address: haithamsaadon@yahoo.com (H.L. Saadon).

https://doi.org/10.1016/j.optmat.2024.114837
Received 3 October 2023; Received in revised form 17 December 2023; Accepted 1 January 2024