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All-photonic switching based on selective input pump polarization states in Fe-doped PbS/PVA freestanding nanocomposite films

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Abstract

A new optical pump–probe technique for all-optical switching is proposed based on three-selective input pump polarization states to pump material simultaneously. The new technique makes it possible to obtain efficient all-optical switching of nonlinear optical materials with very low signal background and increased stability of switching signals. Undoped and Fe-doped PbS/PVA freestanding nanocomposite films are prepared by a simple chemical method at different doping concentrations. The x-ray diffraction patterns and optical absorption spectra of the prepared films are examined. The crystallinity and optical band gap of the prepared Fe-PbS/PVA are found to be affected by Fe doping concentration. The all-optical switching effect of Fe-PbS/PVA freestanding nanocomposite films with various Fe concentrations was investigated. The proposed technique that demonstrates all-optical switching with three-input polarization states can lead to the realization of all-photonic switching at a threshold optical pump power of 19 mW with maximum modulation depth (ON/OFF) of 86% and switching contrast (ON/OFF) of 8.6 dB for a minimum switching time of 43 ms.

Keywords: all-photonic optical switching, PbS/PVA nanocomposite, modulation depth, switching contrast

(Some figures may appear in colour only in the online journal)

1. Introduction

Photonic devices represent the wave of the future in optical communications systems that require all-optical information processing to control light by light [1–4], which is only possible in nonlinear optical (NLO) materials [5–7]. All-optical devices using different optical materials and based on optical nonlinearity have received much attention in recent years [8–14]. However, to produce high-performance, practical all-photonic switching devices, important parameters such as threshold pump power, switching time (ST), switching contrast (SC), and modulation depth (MD) should be controlled [15, 16]. The traditional technique used for all-optical switching of an NLO material is referred to as a pump–probe (PP) setup. Significant efforts have been made to make all-optical switching a reality, such as low signal/noise background in the output of the probe beam and high contrast. Thus, various approaches have been proposed for this particular subject [17–19]. In order to realize all-photonic switching with improved performance, we propose a new PP technique for all-optical switching based on three-selective input pump (TIP) polarization states to pump the material simultaneously. The method consists of three control (pump) beams: a circularly polarized beam (B1), linearly polarized beam (B2), and another linearly polarized beam (B3). The three control beams (B123) pump to the NLO material simultaneously. Thus, this paper describes a new PP-TIP technique with the following improvements:

