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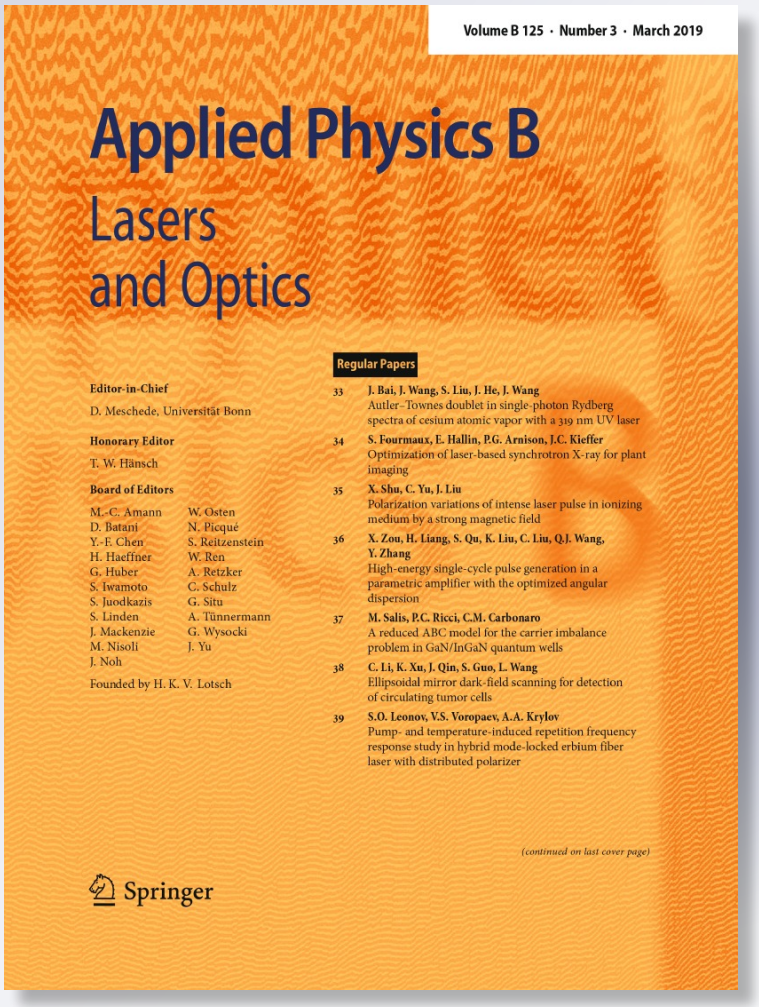

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Structural, morphological, and Z-scan technique for a temperature-controllable chemical reaction synthesis of zinc sulfide nanoparticles

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Abstract
Zinc sulfide (ZnS) nanoparticles were fabricated using a new route chemical reaction technique. During growth, the temperature of the annealing was controlled between 200 °C and 500 °C. The structural, morphological and optical properties of as-synthesized nanoparticles were examined using scanning electron microscopy (SEM), X-ray diffraction and ultraviolet–visible (UV–Vis) absorption. The X-ray diffraction pattern exhibits a wurtzite crystal structure at room temperature. The thermal nonlinear refractive indexes of the ZnSNP films are calculated based on diffraction ring patterns and the *Z*-scan technique. The optical limiting properties were also studied. The efficiency of the optical limiting was found to depend on the temperature of the sample. The mechanism of optical limiting is found to be predominantly of a thermal origin. The evaluation of the figure of merit ($W > 1$) shows that the ZnSNP films are sufficient for application in all-optical switching technology. These results show that the ZnSNPs have potential application in nonlinear optics.

1 Introduction

A class of nanocrystals shaped in low dimension offers the possibility of creating materials with integrated functionalities owing to their size-dependent optical, electric, and mechanical properties. Manipulating and/or designing the structure of these materials will possibly open up their usage in many electro-optical applications such as photo-detectors [1], gas-sensors [2, 3], bio-sensors [4] as well as energy storage devices [5]. Among many well-known nanomaterials and/or structures, ZnS nanoparticles (bandgap for bulk is ~3.77 eV) have been found to be extraordinary beneficial for several applications because of the rapid generation of electron–hole pairs through photo-excitation plus the extremely negative reduction potentials of excited electrons [6]. Numerous techniques have been effectively employed up to now to prepare ZnS nanoparticle such as hydrothermal method [7] and sol–gel method [8]. Although many of the available above-mentioned reports showed the possibility of fabricating high-crystalline zero-dimension ZnS structure, most of these reports did not display the prospect of controlling the optical band structure of ZnS below 3.77 eV.

In this work, we report a new method of creating ZnS nanoparticles through polymer-assisted chemical reaction technique with the contribution of polymer. As per the obtainable literature, there are merely few reports on polymer-assisted synthesis of ZnS nanocrystals. Also, we present the synthesis and study Z-scan of zinc sulfide nanoparticle films with different annealing temperatures; the temperature of annealing was controlled between 200 °C and 500 °C, using laser beam from CW diode laser ($\lambda = 532$ nm). The ZnSNPs exhibit good optical limiting properties at different temperatures. To our knowledge, there is no previous work on the mentioned materials. The aim of our present work is to find the possibility of new applications of the zinc sulfide nanoparticles in the field of the optical modulators.

2 Experimental details

2.1 Reagents and materials

Polyethylene glycol (PEG), zinc acetate ($((CH_2CO_2)_2Zn)$) and thiourea (NH_2CSNH_2) were purchased from Sigma-Aldrich. All these chemicals were used as -received from the company without any additional purification and/or other chemical treatments.

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