Notification No.: 539/2023

Date of Award:05-06-2023

Name of the Scholar: Imran Ahmad Salmani

Name of the Supervisor: Prof. Mohd. Shahid Khan

Name of the Co-Supervisor: Prof. Mohd. Saleem Khan

Name of the Department/Centre: Department of Physics, JMI.

Topic of Research: Non Linear Optical Properties of Multiferroic Nanoparticles

Findings

The nonlinear optical properties of multiferroic nanoparticles have been studied extensively in recent years due to their potential applications in photonics and optoelectronics. Multiferroics are nanomaterials that exhibit both ferromagnetic and ferroelectric properties, and their nonlinear optical properties have been shown to be significantly enhanced in nanoscale form. This is due to the high surface-to-volume ratio, which leads to a large number of nonlinear optical interactions. Overall, multiferroic nanoparticles represent a promising platform for the development of optoelectronic devices with enhanced nonlinear optical properties. Pavana S. V.et al. (2013) and A.Yakubu et al. (2015) studied the size dependent properties and found that size of the nanoparticles is increasing with the increase in sintering temperature and in our experiment we also find the increase in bismuth ferrite nanoparticles size and analysis of size-dependent variation in non-linear absorption coefficient and its multiferroic properties. The prepared nanaoparticles show single-phase rhombohedral structure with R3c space group without any secondary phase. The crystallite size was found to be 75-94 nm. The nonlinear absorption (NLA) coefficient (β) using the 532 nm laser was found to decrease with an increase in the particle size of the BFO NPs. By optimizing the synthesis temperature BFO NPs having different particle size, band gap and NLA coefficient can be synthesized and used for various nonlinear optical and multiferroic applications. One of the experiment was done to find the effect of Sr-Mn co-doping on the multiferroic properties of pure BFO. In this experiment, we found the enhancement in the multiferroic properties (P-E loops and M-H loops) by Sr–Mn co-doping in $BiFeO_3$. The band gap was found to decrease from 2.02 to 1.83 eV on increasing the Sr and Mn codoping in BFO. 10% of co-doping is more effective than others as it shows better enhanced multiferroic values. The NLA coefficient (β) was found to increase with co-doping. In addition,

we doped rare earth element i.e. isovalent Y^{3+} ions substituted in $BiFeO_3$ at the Bi site and find its nonlinearity and multiferroicity. Then $BiFeO_3$, $Bi_{0.95}Y_{0.05}FeO_3$, $Bi_{0.90}Y_{0.10}FeO_3$ and $Bi_{0.85}Y_{0.15}FeO_3$ nanoparticles thin films were used to investigate their optical linear & nonlinear, structural, morphological, and multiferroic properties. It was found that the NLA coefficient increases with intensity and Y^{3+} substitution. It was found that Y^{3+} substituted BFO nanoparticles thin films posses enhanced nonlinear optical and multiferroic properties. Furthermore, a new multiferroic material $ZrFeO_3$ was synthesized by Sol-gel method. Then nanocrystalline thin films were deposited and found their optical, nonlinear optical, structural, morphological, and multiferroic properties. It was found that $ZrFeO_3$ have monoclinic structure with P2m. Different laser power were used to find the NLO properties of the thin film and at each input power, $ZrFeO_3$ thin film shows the reverse saturation absorption (RSA) behavior with nonlinear absorption coefficient (β) of the order of 3.22×10^{-4} cm/W, which was found to decrease with an increase in power. The other findings are the parameters like magnetic parameters i.e. Mr = 0.0042 emu/g and Hc = 0.326 kOe and ferroelectric parameters Pr = 0.667 $\mu C/cm^2$ and Ec = 1.145 kV/cm which confirms the multiferroicity of the $ZrFeO_3$ thin film. The findings of this study confirmed that $ZrFeO_3$ thin films can be used as a candidate multiferroic and nonlinear optical material.