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NLO property and surface morphology of Lead Iodate Crystals Doped with Zinc

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ABSTRACT

Lead iodate crystals doped by Zn(II) were grown by silica gel method. Grown crystals were characterized by scanning electron microscopy (SEM), Energy dispersive X-ray spectroscopy (EDAX), X-ray fluorescence spectroscopy (EDXRF) and Non linear optical (NLO) property. SEM pictures shows that no morphological or structural changes take place due to doping. An EDXRF and EDAX study reveals the presence of zinc in doped crystals. The NLO property of the crystal was tested by Nd:YAG laser.

Key words: SHG test, SEM, EDAX and EDXRF.

INTRODUCTION

An NLO material is a compound in which a nonlinear polarization is invoked on application of an intense electric field. This electric field results from the external application of an intense laser-source. The nonlinear material is different from the linear material in several aspects. A nonlinear material is one, whose electrons are bound by very short springs. If the light passing through the material is intense enough, its electric field can pull the electrons so far that they reach the end of their springs. The restoring force is no longer proportional to the displacement and then it becomes non-linear. The electrons are jerked back roughly rather than pulled back smoothly and they oscillate at frequencies other than the driving frequency of the light wave. These electrons radiate at the new frequencies, generating the new wavelength of light. The exact values of the new wavelengths are determined by conservation of energy. The energy of the new photon generated by the nonlinear interaction must be equal to the energy of the photons used.

Reports on zinc-doped lead iodate crystals in particular are scanty in the literature. To the best of my knowledge, effect of zinc doping on the SEM, EDXRF and NLO properties of lead iodate is reported for the first time.

MATERIALS AND METHODS

Experimental

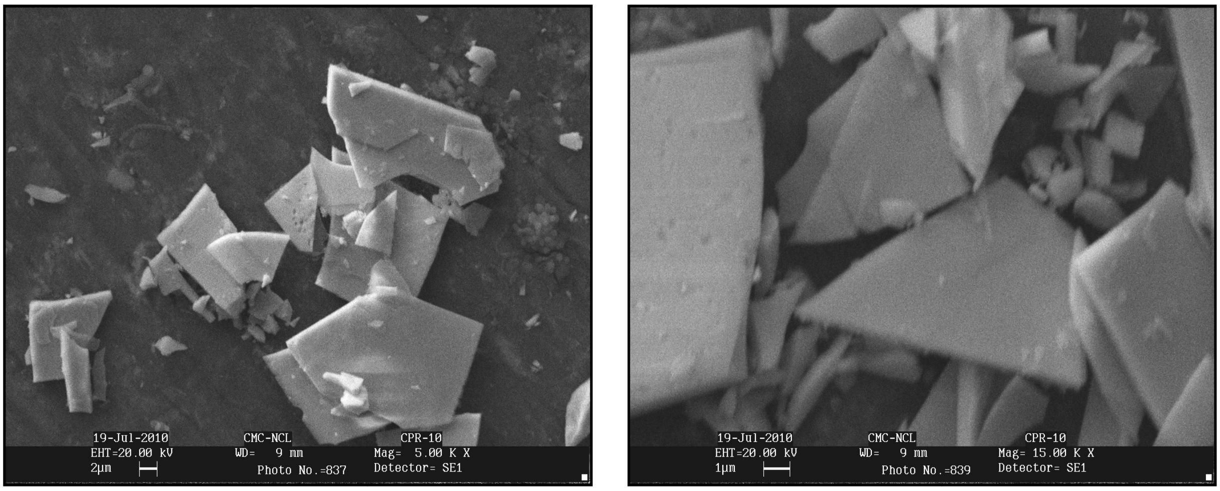
Zinc-doped lead iodate crystals were grown in silica gel using single diffusion technique. The concentration of zinc dopant was 0.04M. Its growth and XRD analysis is already reported [1].

In the present work powdered sample of Zn(II) doped lead iodate crystals was examined by using LEICA S440 SEM instrument at the National Chemical Laboratory, Pune. An elemental composition were carried out to know the chemical composition of the elements using FEI quanta 200 3D EDAX instrument at National Chemical Laboratory, Pune. The elemental composition of the grown crystals was also verified with X-ray fluorescence spectrometer. EDXRF was carried out using Horiba XGT-7200 instrument at Gemmological Institute of India, Mumbai. Kurtz and Perry powder SHG test [2] was carried out at the Department of Inorganic and Physical Chemistry, Indian Institute of Science (IISC), Bangalore.

RESULTS AND DISCUSSION

Scanning electron microscopy (SEM):

Figures 1(a) illustrate the SEM image of single crystals of 0.04M zinc-doped lead iodate crystals. All SEM images shows plate like crystal morphology and crystals are grown by layer deposition. Thick and thin layers are seen in figures. The individual plates of samples are flat and the plates with the sharp edges were observed. On some plates further plate like growth was observed. Higher magnification SEM images are shown in figures 1(b) shows more clearly layer structure of doped crystals [3]. The SEM images of lead iodate crystals are reported [4]. It was found that no morphological or structural changes take place due to doping.



(a) (b)

Figure 1: (a) SEM picture of 0.04M Zn-doped lead iodate crystals and (b) magnified SEM picture

Energy dispersive X-ray spectroscopy (EDAX):

Figures 2 shows EDAX spectrum of zinc-doped lead iodate doped crystals. The peaks show the presence of lead, iodine, oxygen and zinc in the doped crystals. This is a clear indication of presence of the zinc dopant in the crystals. Table 1 shows the elemental and atomic percentage of the elements Pb, I, O and Zn in the doped crystals. It was observed that atomic % of Pb, I and O are in good agreement with stoichiometrically expected atomic % 11.11, 22.22 and 66.66 respectively.

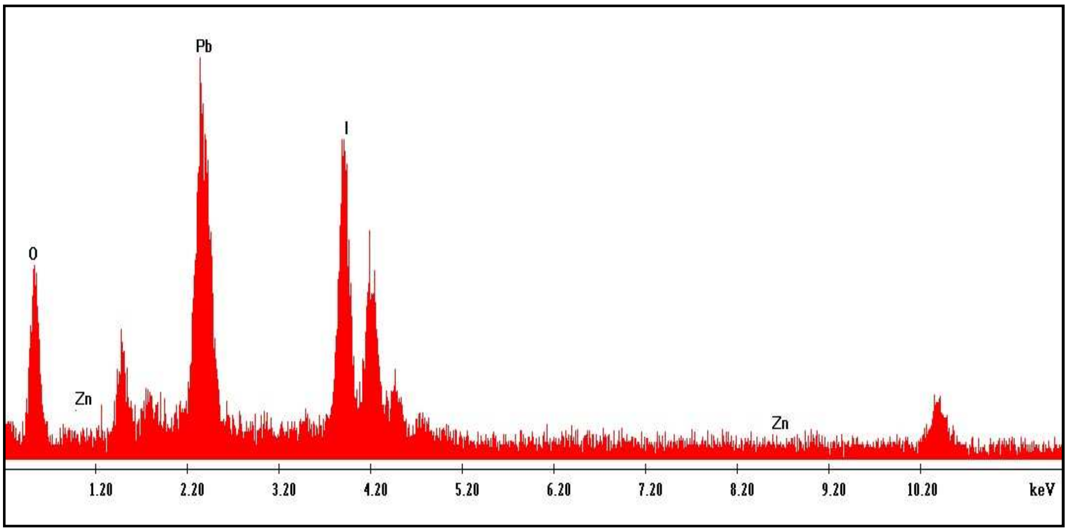


Figure 2: Energy dispersive spectrum of 0.04M Zn doped lead iodate crystal

Table 1 Values of elemental content of $Pb(IO_3)_2$: Zn crystals

Elements	Experimental values	
	Weight/%	Atomic/%
Pb M	41.16	12.58
I L	41.33	20.62
O K	16.66	65.97
Zn K	0.85	0.83

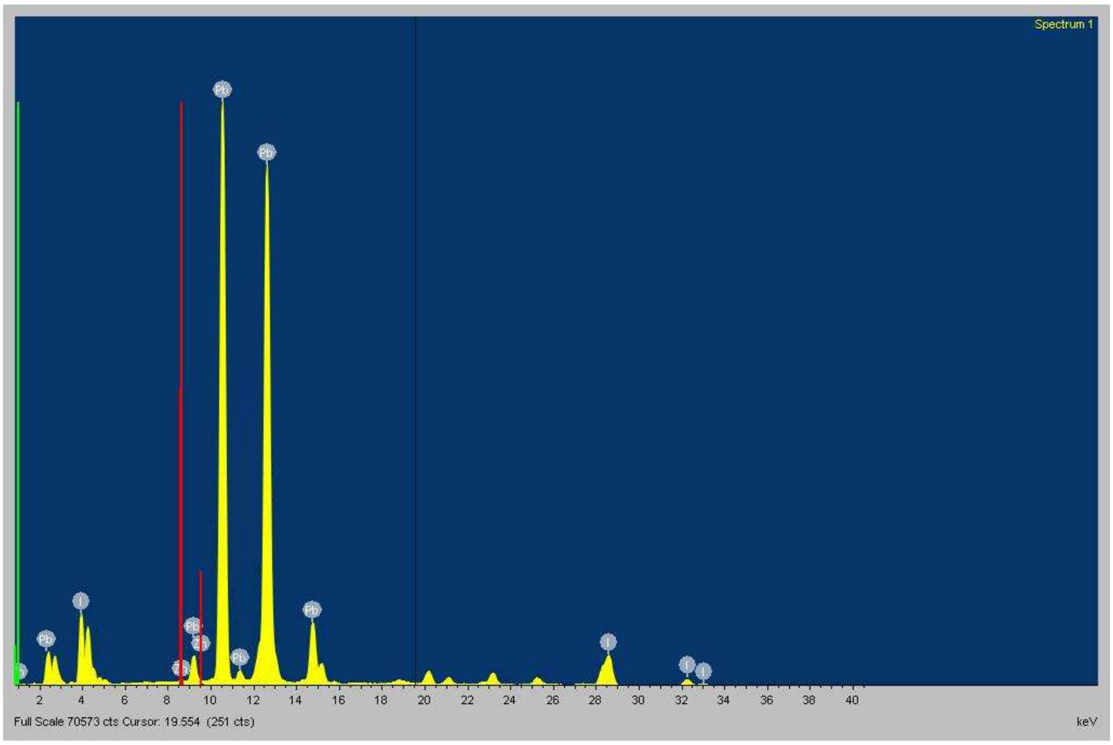


Figure 3: EDXRF spectrum recorded for zinc-doped lead iodate crystal

Energy dispersive X-ray fluorescence (EDXRF):

XRF was performed at the selected region of sample. The result is given in Table 2. From the result, it is concluded that there is little deviation in weight % and atomic % of the grown crystals from the theoretically calculated values.

Figure 3 shows the EDXRF spectra of 0.04M zinc-doped lead iodate crystals. The spectrum shows strong peaks of Pb and I which indicates the presence of Pb and I in the sample. The weak peak of Zn shows that very little amount of zinc is doped in the crystals lead iodate.

Table 2 Elemental compositions of 0.04M Co doped lead iodate crystal

Elements	Line	Experimental values		Theoretically calculated values		Intensity [cps/mA]
		Mass[%]	Atomic[%]	Mass[%]	Atomic[%]	
53 I	K	43.58	21.67	45.567	22.22	2936.37
82 Pb	L	38.60	12.07	37.199	11.11	25125.38
29 Zn	K	1.02	1.21	--	--	23.11
O		16.80	66.25	17.234	66.66	--

Non linear optical (NLO) property:

The crystals were ground to homogeneous powder and tightly packed in a micro capillary tube and mounted in the path of laser beam. Q-switched Nd-YAG laser with the first harmonic output of 1064 nm, pulse width 10 ns and pulse energy of 2 mJ / pulse was used. of pulse energy 5 mJ. The SHG was confirmed by the emission of green light (532 nm) collected by photomultiplier tube and displayed on the oscilloscope. SHG signals of intensity of 20 mV, 4.1 mV and 4.8 mV were obtained through KDP, undoped and 0.04M Zn doped lead iodate crystals respectively. Zn(II) doping significantly improves the nonlinear optical property [5] and it increases with the increase in concentration of dopant hence Zn is useful dopant.

CONCLUSION

In conclusion, SEM pictures shows that surface morphology was not affected significantly due to zinc doping. EDAX and EDXRF confirms the presence of zinc in the crystals. 8. NLO studies reveal that SHG efficiency of lead iodate crystals is enhanced by zinc dopant.

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