Synthesis, Optical and Mechanical properties of Basic Violet dye doped KDP single Crystal

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Abstract : Potassium Dihydrogen Orthophosphate (KDP, KH_2PO_4) single crystal doped with Basic Violet ($C_{25}H_{30}ClN_3$, Crystal Violet) dye were successfully grown by slow evaporation method at room temperature with deionized water as a solvent to the aim of improve the properties of KDP crystal. The concentration of Basic Violet dye 0.1mol% and 0.2mol% were considered while synthesis of KDP crystal. The cut-off wavelength and energy band gap were determined by UV-Vis spectral analysis. Mechanical property of the crystal was determined by Vickers hardness tester. Micro hardness of the crystals was measurement with different dwell time and different load.

IndexTerms - Slow evaporation method, doping, UV-VIS, Vicker hardness.

I. Introduction

Nonlinear optical (NLO) crystals play a major role in nonlinear optics and they have a great impact on both academically and industrially applications [1,2]. The nonlinear optical crystals have been interested to researchers because of their wide application such as second harmonic generation (SHG) optical modulation, high-speed information processing, integrated photonics, color displays, frequency shifting, telecommunication, photonic laser, microelectronic, optical signal processing [3-7]. Review of literature shows growth and characterization of pure and dopant KDP crystal has been reported to shown improvement in material characteristics.

In a present work we grow 0.1mol% Basic Violet dye doped KDP crystal and 0.2mol% Basic Violet dye doped KDP crystal by slow evaporation method in solution growth method at room temperature. The UV-Vis spectral analysis and Mechanical property by vicker microhardness of the crystal was determined.

II. Experimental

2.1 Crystal Growth Method

For the preparation of seed crystal, super saturated solution of KDP was prepared in deionized water which was then filtered and solution was kept in a Petri dish covered to get the slow evaporation and allowed the crystal to grow for 20days. After 20 days seed crystals of KDP was harvested as shown in figure 1.

Figure 1: Seed KDP crystal

For a crystal to growth the super saturated solution of KDP (200 ml) prepared with deionized water and filtered by whatman filtered paper. Two similar beakers each with 100ml super saturated KDP solution; the first beaker doped with 0.1mol% Basic Violet dye and second beaker doped with 0.2mol% Basic Violet dye were stirred using temperature controlled magnetic stirrer for 120 minutes for homogeneous mixture. The two seeds were tied with a nylon thread and suspended into a beaker filled with two different concentration doped solutions. The solution was covered for slow evaporation and was kept undisturbed for 30 days. After 30 days, transparent crystals of 0.1mol% Basic Violet dye doped KDP crystal and 0.2mol% Basic Violet dye doped KDP crystals were harvested as shown in Figure 2 and Figure 3 respectively. Seed KDP crystal is colorless while Basic violet doped crystals have light sky blue color.

Figure 2: 0.1mol% Basic violet dye doped KDP crystal

Figure 3: 0.2mol% Basic violet dye doped KDP crystal

III. RESULTS AND DISCUSSION

3.1 Mechanical property

The hardness is a not well defined material property because of experiment dissimilarly among the various techniques. Hardness conversion is also depends on material type and characteristic. The micro hardness of a materials are depends on different parameters such as lattice energy, temperature, heat of formation and interatomic spacing [8]. The mechanical properties of the grown crystals were studied by Vickers hardness tester. The applied loads were 5, 10 and 50 gm. For each load P, dwell times of indentation were 5sec and 10 sec taken. Indentations are made on the sample and two diagonal lengths a and b of the indentation impressions is measured. The hardness of the material, Hv is using the relation,

$$Hv = 1.8544 \text{ x } \frac{P}{d^2} \text{ } vickers \qquad (1)$$

Where, P is the applied load in kg and d is the mean diagonal length in mm.

The experimental values of microhardness of 0.1mol% Basic violet dye doped KDP crystal and 0.2mol% Basic violet dye doped KDP crystal are shown in table 1 and 2 respectively and Figure 4 and figure 5 shows the variation of hardness number with the applied load with different load.

Table 1. Microhardness of 0.1mol% Basic violet doped KDP crystal

Load P (gf)	**Dwell time (sec)**	**Vertical X (microns)**	**Horizontal Y (microns)**	**Mean $D=\frac{X+Y}{2}$ (microns)**	**Harness $H=1.854x\frac{P}{D^2}$ (vickers)**
10	5	7.1	7.1	7.1	367.78
	10	7.1	7.0	7.05	373.019
25	5	12.0	12.0	12.65	289.64
	10	12.7	12.4	12.55	294.28
50	5	19.1	17.6	18.35	275.30
	10	18.7	17.4	18.05	284.52

Table 2. Microhardness of 0.2mol% Basic violet doped KDP crystal

Load P (gf)	**Dwell time (sec)**	**Vertical X (microns)**	**Horizontal Y (microns)**	**Mean $D=\frac{X+Y}{2}$ (microns)**	**Harness $H=1.854x\frac{P}{D^2}$ (vickers)**
10	5	8.1	8.2	8.15	279.12
	10	8.0	8.4	8.2	275

25	5	14.3	12.8	13.55	252.44
	10	13.8	14.2	14	236.47
50	5	19.4	20.8	20.1	229.44
	10	19.6	19.6	19.6	241.30

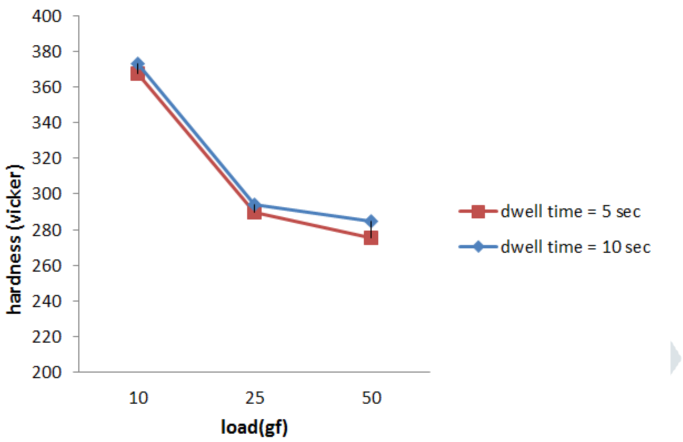

Figure 4. Graph of Microhardness of 0.1mol% Basic violet doped KDP crystal

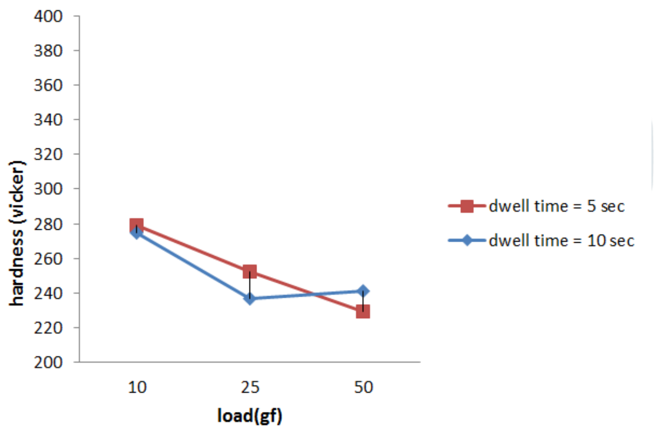

Figure 5. Graph of Microhardness of 0.2mol% Basic violet doped KDP crystal

3.2 Ultra Violet Visible Spectroscopy (UV-VIS)

The transmission spectrum was observed at room temperature using carry 5000 UV – Vis spectrometer in the range of 200nm to 800nm. The crystal is transparent in the visible range. For optical energy band gap of the 0.1mol% basic violet dye doped KDP crystal and 0.2mol% basic violet dye doped KDP were determine from the absorption spectrum using the relation of equation. 2.

$$Eg = \frac{hC}{\lambda} \qquad (2)$$

Where, Eg = optical energy band gap, h = Planck's constant = 4.135 x 10^{-15}ev.s, c = velocity of light = 3 x 10^{-8} m/s and λ = intercept of straight line [9].

UV-Vis spectra showed that the grown crystal was optically transparent through 200-800 nm and also suggested the suitability of the material for optical devices. As the wavelength increases it leads to increase the percentage of transmission for each crystal. UV-vis transmission spectra of 0.1mol% Basic violet dye doped KDP crystal and 0.2mol% Basic Violet dye doped KDP crystal are shown in Figure 6 and Figure 7 respectively. The intercept of straight line on the wavelength λ and optical energy band gap Eg for all three crystals are shown in Table 3.

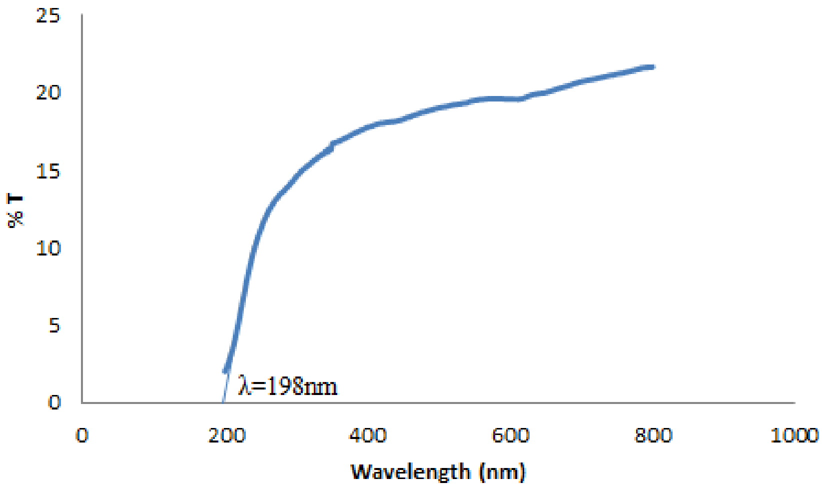

Figure 6. Uv-Vis spectra for 0.1mol% Basic Violet doped KDP crystal

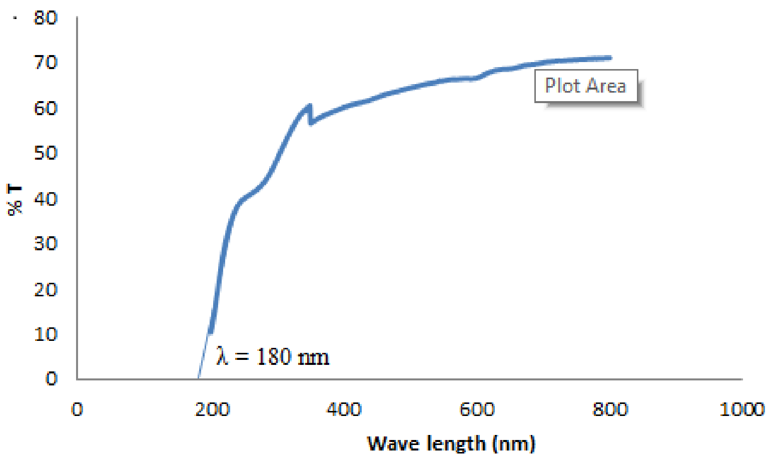

Figure 7: Uv-Vis spectra for 0.2mol% Basic Violet doped KDP crystal

Table 3: Intercept of straight line on the wavelength λ and optical energy band gap Eg.

Sr. no	Crystal	The intercept wavelength λ(nm)	Optical energy band gap Eg (ev)
1	0.1 mol% Basic violet doped KDP crystal	198	6.20
2	0.2 mol% Basic violet doped KDP crystal	180	6.89

IV. CONCLUSION

0.1mol% Basic violet dye doped KDP single crystals and 0.2mol% Basic violet dye doped KDP single crystal are grown by slow evaporation method at room temperature with deionized water as solvent. The microhardness 0.2mol% Basic violet dye doped KDP crystal are found to be less than the 0.1mol% Basic violet dye doped KDP crystal. UV- VIS spectroscopy showed Optical energy band gap of both crystal are more than 4ev. Optical energy band gap of pure KDP crystal is 6.17ev while doping of Basic Violet dye in KDP crystal optical energy band gap are increasing. Optical energy bandgap of all Crystals are more than 4ev. So that all crystal having insulating material.

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