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Uncovering the influence of Ni^{2+} on optical and dielectric properties of $NH_4H_2PO_4$ (ADP) crystal

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ABSTRACT

Ammonium dihydrogen phosphate (ADP) crystal hold strong impetus in photonic industries for distinct applications therefore in current investigation slow solvent evaporation technique has been employed to grow pure and Ni^{2+} ion doped ADP crystal at room temperature and emphasis was given to explore the synchronized influence of each mole concentration of dopant Ni^{2+} ion on studied properties of ADP crystal. The qualitative analysis of grown crystals has been achieved by means of energy dispersive spectroscopic analysis. The grown crystals were subjected to single crystal X-ray diffraction analysis to determine the crystal structure, space group and unit cell dimensions. The UV–vis spectral analysis has been employed within wavelength range of 200–900 nm to uncover the effect of increasing concentration of Ni^{2+} ion on optical transmittance of ADP crystal. The pure and Ni^{2+} ion doped ADP crystals were subjected to dielectric measurements at 30 °C to assess the frequency response of dielectric constant and dielectric loss.

1. Introduction

In last few decennia ammonium dihydrogen phosphate ($NH_4H_2PO_4$, ADP) single crystal has gained considerable attention owing to interesting and unique ferroelectric [1], electro-optic, piezoelectric and nonlinear optical features [2,3]. The occurrence of foresaid versatile features in ADP crystal extends its credibility and limit of applications in designing/tuning ellipsometry [4], transducers, monochromators, frequency convertors, electro-acoustic, optical parametric oscillators, electro-optic modulators, photonics, optical switching and memory storage devices [5–7]. Numerous attempts have been outsourced for growing an excellent quality ADP crystal. One of the most convenient and influential ways of optimizing the tendency of characteristic properties of ADP crystal is introducing an external impurity in the crystallite. The literature study evidences that the metallic impurities are exceptionally vital and reinforce significant impact on growth, morphology and overall performance of ADP crystal. The influence of cobalt [8,9], potassium [10], sodium [11] and sodium metasilicate [12,13]

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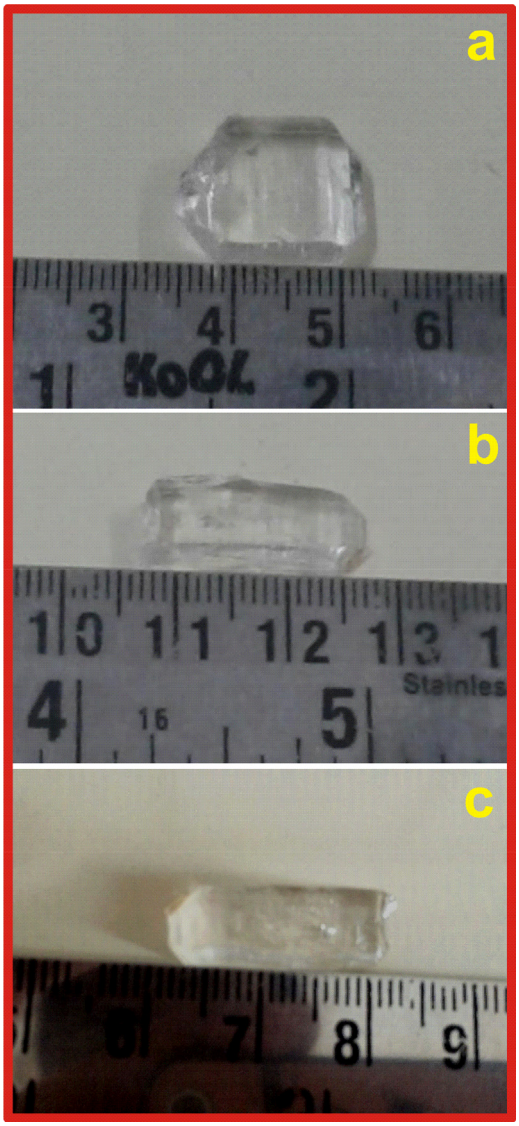

Fig. 1. (a) Pure ADP (b) 0.05 mol Ni-ADP (c) 0.1 mol Ni-ADP.

on optical, electrical, mechanical and thermal properties of ADP crystal has been extensively studied. Interesting fact is that the doping effect of high concentration like 1, 2.5 and 5 mol of dopant Ni^{2+} on ADP crystal has been exclusively investigated in literature [14,15] and it revealed that the specific concentration of dopant have crucial impact on morphology, microscopic, optical, mechanical and dielectric properties of ADP crystal. It is worth mentioning that concentration of dopant plays vital role in tuning the properties of host crystal at the same time the actual concentration of dopant incorporated in crystallite is much less [16] this fact encouraged our group to dope lower concentration of dopant Ni^{2+} and systematically investigate the modifications in properties of ADP crystal. In current investigation the synchronized effect of small quantity of Ni^{2+} (0.05 mol and 0.1 mol) has been doped in ADP crystal to examine the structural, optical and electrical properties. The comparative analysis of pure and Ni^{2+} doped ADP crystal have been accomplished by means of energy dispersive spectroscopy, single crystal XRD, UV–vis and dielectric characterization studies.

2. Experimental procedure

The high quality AR grade salts of ammonium dihydrogen orthophosphate (ADP) and nickel chloride were taken as starting materials with double distilled water. Initially in two separate beakers 1 mol% of ADP salt was dissolved in double distilled water and stirred well to prepare the homogeneous solution of host material. In order to dope Ni^{2+} the 0.05 and 0.1 mol of nickel chloride was precisely measured and independently added in the separate beakers containing the homogeneous solution of ADP material. The two beakers were allowed to stir well at constant speed for five hours and later filtered in a