Indian J. Res. Found., (2015) 2, 17-19. ISSN 2454-6577

INDIAN JOURNAL OF RESEARCH FOUNDATION

www.indianjournal.net

RESEARCH ARTICLE

Growth, luminescence, dielectric and photoconductive properties of α-Nickel sulphate hexahydrate for UV filter applications

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Received 27 June 2015; Accepted 30 August 2015

Available online 31 August 2015

Abstract

In the present study, the <001> directed alpha Nickel Sulphate hexahydrate (NSH) crystals was grown by Sankaranarayanan Ramasamy (SR) Method, mainly because of the required (0 0 l) face for device performances. Superior characteristics of photoluminescence and dielectric properties of SR method grown NSH single crystal were observed. In addition the violet luminescence, dielectric and negative photoconductivity behavior of the NSH crystal was discussed.

Keywords

Inorganic compound

Sankaranarayanan Ramasamy method

Photoconductivity

Photoluminescence

Introduction

Crystals have been a huge part in the development of technology providing a wide arena of diverse applications owing to their various properties and characteristics. **α**-Nickel sulfate hexahydrate is one such crystal widely used for UV light filters and UV sensor applications [1-3]. The wavelength lies in the ultraviolet spectrum of electromagnetic radiation, which is an active subject of research with respect to the potentiality of applications. This crystal has the Potency to be used to detect missiles flawlessly when used as an optical filter. This potential glimpse from the future application motivated us to study the photoluminescence properties of the crystal in the UV spectrum. In order to bring high quality crystals into reality in accessible and feasible in commercial usage, the enhancement and sophistication is required in the crystal growth processes. SR method is one such method to grow bulk single crystals from solution with the superior characteristics than the crystals grown from other methods [4, 5]. In the present study, the bulk size NSH single crystal was grown by SR method. In addition the photoconductivity and dielectric properties of grown crystals have studied and discussed.

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Experimental

Crystal growth

SR method was employed to grow bulk size <001> directed NSH crystals (**Fig 1**), mainly because of the required (0 0 l) face for UV filters. The uncomplicated growth apparatus was made up of a glass container of size 30 x 30 x 30 cm^3 and ampoule of inner diameter 20 mm using two controllable ring heaters, transparent growth vessel, and temperature sensors. Based on the quality of the crystals grown by conventional method, a suitable seed crystal was selected for single crystal growth of particular orientation. To control the spurious nucleation, care was taken while preparing the growth vessel and the solution. The chosen plane of the seed crystal was mounted in the bottom of the ampoule without polishing the surface. Filtered solution was transferred carefully into the growth vessel. The ring heater at the top of the growth solution controls the spurious nucleation near the surface region of the solution during the entire growth period. Under this optimized condition highly transparent crystal growth was seen after a one weak duration. After 40 days of the growth period, a good-quality crystal was harvested with size 20 mm in diameter and 150 mm in length. Finally, the ampoule was detached from the growth system and the grown crystal is carefully removed from the ampoule using diamond glass cutter. The harvested crystals will be cut along the <0 0 1> direction for the fabrication of band pass filters.

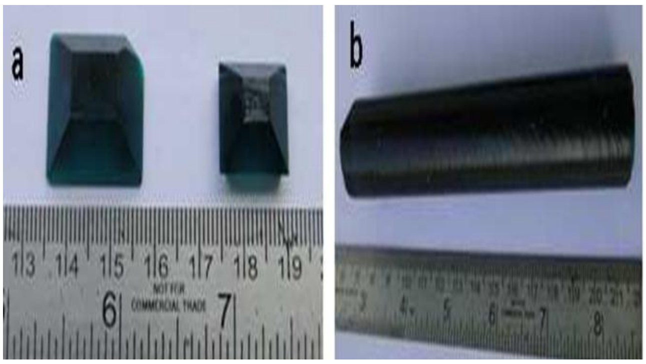

Fig 1 1NSH crystal grown by (a) conventional method and (b) SR method.

Results and discussion

Photoluminescence (PL) is one among the important properties to be investigated on crystals. The materials were excited at 358 nm and the corresponding excitation and emission spectrum was shown in the **Fig 2**. The emission starts at 358 nm, again lying in the ultraviolet region and falls off progressively.

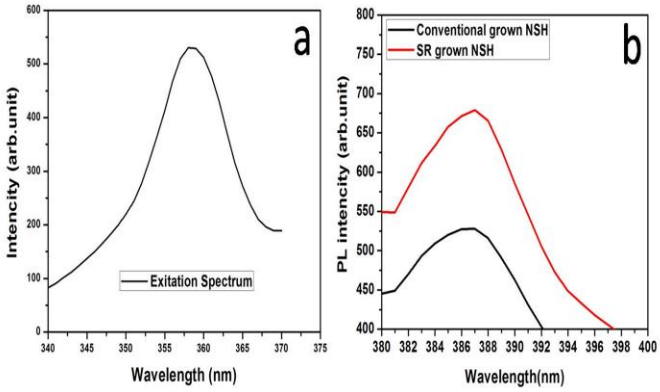

Fig 2 (a) Excitation and (b) emission spectrum of grown NSH crystal.

The PL emission peaks for the conventional and SR method grown crystal look similar and intensity occurring at about 387 nm. It represents the grown crystals have violet luminescence characteristics. The intensity of radiation from the SR method grown crystal is found to be higher than the conventionally grown one at all wavelengths in the given range. It confirms that the SR method grown NSH crystal exhibits superiority in characteristics with respect to photoluminescence. The conventionally grown crystal exhibits photoluminescence only upto 392 nm after which the intensity drops whereas the SR method grown crystal exhibits the same property upto a slightly longer wavelength, about 397 nm. The higher intensity of PL response of SR grown crystals is because of the absence of scattering centers in the grown crystals.

An Impedance analyser was used to measure dielectric properties of <001> directed NSH crystal as a function of frequency from 1 KHz to 1 MHz at ambient environment. In order to make contact with the electrodes, high-quality silver paste was used on both the sides of the plane surface. The prepared sample was placed between the two electrodes and the measurements were carried out with the sample. The variation of dielectric constant with various frequency of crystals grown by conventional and SR method is shown in **Fig 3**. In which the crystal exhibits high value at low frequency. It may be due to all the four polarizations namely space charge, dipolar, ionic and electronic polarizations accumulating charges in between sample and electrodes, but at higher frequency is only due to the contribution of ionic and electronic polarisations. The characteristics of higher dielectric constant of SR grown crystal than conventional grown crystals with frequency suggests that the crystal posses enhanced optical quality and lesser defects and this parameter plays a vital role in optoelectronic applications [6]. The V-I (photoconductivity) characteristics of the conventionally grown alpha NSH crystal and a SR grown crystal are shown **Fig 4**.

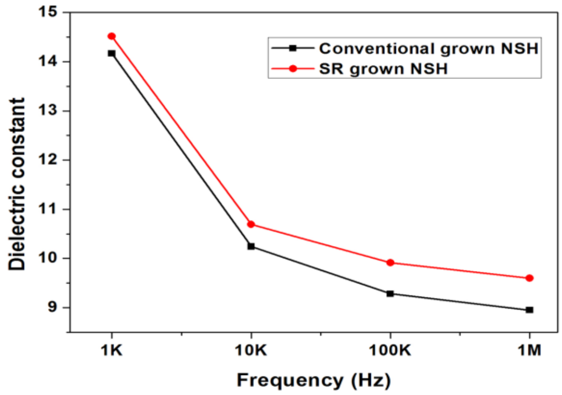

Fig 3 Plot of dielectric constant of NSH crystals grown by conventional and SR method.

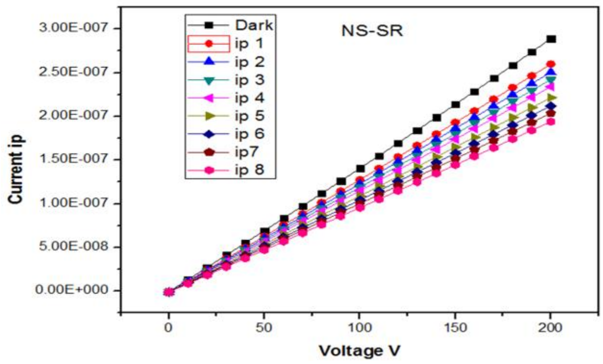

Fig 4 V- I characteristics of grown NSH crystal.

The V-I characteristics of the SR method grown crystal exhibit good linearity over the range of 0 to 200 Volts. The overall conduction current is in the range of 10^{-8}A. The photoconductivity of the material decreases with increase in the incident light energy on the crystal. As sooner the sample is irradiated by light, the recombination of charge carrier take place, resulting in decrease in number of mobile charge carriers and their life time [7]. Hence, the crystals exhibit the phenomenon of negative photoconductivity.

Conclusions

The bulk size <001> directed NSH single crystal was successfully grown by SR method of size 150 mm X 20 mm. The positive impact on the dielectric and photoluminescence properties of NSH single crystal grown by SR method represents the good quality of the grown NSH crystal. The photoluminescence, dielectric and photoconductivity properties of the grown single crystal are studied and it is enunciated owing to their potential applications. The photoconductivity analysis reveals the negative photoconductivity of NSH crystals.

Acknowledgments

The authors gratefully acknowledged SSN trust for the financial support. Also, the authors are thankful to Prof. C. Dennison, Department of Physics, S.T Hindu College, Nagercoil for providing the dielectric facility.

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