Investigation on growth and characterization of unidirectional 2-amino-5-nitropyridine NLO single crystals adducts for laser generation

Investigator:

Dr. M. Ambrose Rajkumar

Statement of the Problem:

Swift heavy ion (SHI) irradiation is now considered as an advanced technique to modify structural, optical, optoelectronic, thermal, mechanical, nonlinear optical (NLO) properties of crystals through intense electronic energy deposition. Tremendous energy (few tends of M eV to few G eV) deposition to the material can produce various changes in the material. Using SHI beam irradiation one can create new defects as well as anneal out pre-existing defects in materials. SHI is also used to produce materials with novel properties, which cannot be generated by any other means.

In this present work, newer variety of 2-amino-5-nitropyridine family NLO crystalline derivatives were grown using slow evaporation method and bulk crystal of 2-amino-5-nitropyridinium dihydrogen phosphate (2A5NPS and 2A5NPCl) was grown using Sankaranarayanan- Ramasamy (SR) method. Though semiorganic nonlinear optical (NLO) single crystal combined the advantages of both organic and inorganic, the efficiency of second harmonic generation (SHG) and other physico- chemical properties are to be modified further for enhanced device fabrication.

Objectives:

In this modern era, high efficient nonlinear optical (NLO) materials has obtained more attention due to their potential applications, such as high-speed information processing, optical communications, optical communications, and optical data storage. Among the class of NLO materials, the inorganic material possesses high melting point, high mechanical strength and high degree of chemical inertness. But, their optical nonlinearity is poor.

Whereas, organic compounds are having high nonlinearity due to the weak van der Waals and hydrogen bonds and possess high degree of delocalization. However, the difficulty is to grow the large and optically good quality single crystals for device applications. These drawbacks of organic and inorganic crystals may be overcome by semi-organic materials, which share both the properties of inorganic and organic materials. Hence, much interest is focused even now in search of semiorganic crystals due to its widespread application in optical parametric amplifiers, optical switching, optical communications, image processing and photonics.

Methodology

Sankaranarayanan-Ramasamy (SR) Method

Sankaranarayanan- Ramasamy method has been developed to grow large size single crystal in a particular direction. It is one of the methods to grow the crystals from solution. In comparison with other methods for single crystal preparation this method easily controlled the orientation and it achieves a higher crystallization rate. Simple and less expensive experimental set up of this method can be easily installed in any laboratory. At present, there is a lot of literature available which made use of SR method to grow crystals of different kinds like organics, inorganics and semiorganics.

Experimental setup of Sankaranarayanan- Ramasamy (SR) method

Results:

In this research, attempts were made to enhance the physical and chemical properties of 2-amino-5-nitropyridine family NLO crystalline derivatives using Au^{3+} swift heavy ion (SHI) with three different ion fluences (10^{13} ions/cm^2, 5 x 10^{13}ions/cm^2, and 10^{14} ions/cm^2) The as grown bulk crystals from Sankaranarayanan-Ramasamy (SR) method cut and polished for swift heavy ion (SHI) irradiation. Cut and polished crystals (~ 1mm) were irradiated. After irradiation, crystals were subjected to various characterizations.

Modifications in the structural, optical, electrical, thermal, mechanical and nonlinear optical (NLO) efficiency of irradiated crystals with virgin (pristine) NLO single crystals were investigated. It was understood from the X-ray diffraction that lattice was deformed due to the formation of defects and lattice deformation was taken place only in a small area. It was noticed in the optical properties that absorption was increases and energy band gap was changed due to the intermediated energy levels created by SHI. Microhardness and dielectric constant of Au^{3+} ion irradiated crystals increased due to the formation of defects and also fluorescence decreased due to the internal residual stress. SHI affected the non-centrosymmetric molecules of the grown crystals and NLO efficiency were decreased. Thermal stability of the Au^{3+} irradiated crystals was increased and degree of crystallinity was decreased by SHI. SEM image of Au^{3+} irradiated crystal revealed that surface was damaged heavily. Impedance of the pristine and irradiated crystals was also studied.

Publications:

1. Irradiation effect of Au^{3+} on 2-amino-5-nitropyridinium sulfamate (2A5NPS) NLO single crystal, AIP Conference Proceedings, 2270, 100002-1–100002-6; **Scopus indexed**

2. Swift heavy ion (au3+) irradiated 2-amino-5-nitropyridinium chloride (2A5NPCl) nonlinear optical (NLO) single crystal, International journal of research and analytical reviews, 2021, January 2021, Volume 8, Issue 1.

3. Dielectric, Microhardness and Thermal Properties of Swift Ion (Au3+) Irradiated NLO Single Crystal: 2-Amino-5-Nitropyridinium Sulfamate (2A5NPS), IOP Conf. Series: Materials Science and Engineering, 1124 (2021) 012005, doi:10.1088/1757-899X/1124/1/012005- **Scopus indexed.**