IRRADIATION EFFECTS ON AMMONIUM PENTA BORATE (APB) SINGLE CRYSTALS

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Abstract. Single crystals of ammonium penta borate (APB) were irradiated with 120 MeV Ag9+ swift heavy ions (SHI) of fluence 1x1013 ions/cm2. The UV-visible spectrum of irradiated crystal shows slight shift in the absorption edge and it also indicates the non uniformity in its absorbance level. An attempt was made to explain the surface damage caused due to SHI irradiation using AFM and SEM images.

1. Introduction
Borate crystals find commercial application as laser hosts, non-linear optical (NLO) elements, and UV optics [1-2]. In borate crystals, the boron atom usually coordinates with either three or four oxygen atoms forming [BO3]3- or [BO4]5- groups [3]. There are several UV nonlinear optical (NLO) crystals that can produced deep-UV coherent light by harmonic generation. For example, by using fifth harmonic generation (FHG) BBO and KB5 (KB5O8 .H2O) can produce 189 and 195 nm respectively [4]. Ammonium penta borate (APB) is a biaxial crystal of the orthorhombic system and belong to the mm2 (C2v) class [5]. The lattice parameter are a =11.34Å, b = 11.03 Å and c =9.237 Å. The crystallographic elastic and piezoelectric properties of APB crystals have been reported by Cook and Jaffe [6]. We have concentrate swift heavy ion (SHI) effects on APB single crystals.

2. Experimental
Single crystals of ammonium penta borate were harvested using slow – solvent evaporation technique. These crystals were cut in to pieces of dimensions 4 × 4 × 1 mm3 and polished using alumina paste. 120 MeV Ag9+ ions with fluence rate of 1x10 13 ions/cm2 from the 16MV Tandem pelletron accelerator at Inter University Accelerator Centre, New Delhi, India. The incident beam current density was about 3 pnA/cm2. The samples are mounted on a target ladder inside a vacuum chamber pressure 3 × 10−7 Torr.
3. Results and Discussion

3.1 Optical absorption spectrum

The UV-Vis-NIR analysis of non-irradiated and irradiated crystals was carried out between 200 and 2500 nm covering the entire near ultra-violet, visible and near infrared regions, using the VARIAN CARY 5E model spectrometer. From the optical-absorption studies exhibits the bandgap of irradiated sample is less when compared to the non-irradiated sample is shown in Fig. 1. The decrease in bandgap of irradiated sample due to the SHI irradiation. It can create some intermediate energy levels due to the structural rearrangements.

![Optical absorption spectra of pure and Ag9+ irradiated APB single crystals](image)

**Figure 1.** Optical absorption spectra of pure and Ag9+ irradiated APB single crystals

3.2 Atomic Force Microscopy (AFM) studies

The AFM topographical images of as grown and irradiated crystals are shown in Figs. 2 and 3 respectively. The surface roughness of the non-irradiated and irradiated single crystals was also studied. There is no defect are observed by non-irradiated crystal, but the formation of the craters and hillocks were present on the irradiated crystal. The formation of craters and hillocks are due to the SHI irradiation in APB single crystals.

![AFM and 3D image of Pure APB single crystal](image)

**Figure 2.** AFM and 3D image of Pure APB single crystal

![AFM and 3D image of Ag9+ ion irradiated APB single crystal](image)

**Figure 3.** AFM and 3D image of Ag9+ ion irradiated APB single crystal

3.3 Scanning Electron Microscopy studies

Scanning Electron Microscopic (SEM) study on the as grown and irradiated samples were carried out using Hitachi scanning electron microscope model S-4200 operated at 25 kV for different magnifications, after coating the samples with gold layer of 100 Å with Hitachi vacuum evaporator model Oxford 6566. The presence of micro inclusion is identified in the as grown APB single crystal (Fig. 4). When the crystal is subjected to the SHI irradiation it leads to a distorted lattice arrangement and also the generation of shock waves in the medium and this is confirmed by the tiny bubbles and the irregular shapes as observed in Fig. 5.
4. Conclusion

The Ag$^{9+}$ ion induced modification on the optical, structural and dielectric properties of the solution grown APB crystal was studied. The optical absorption study indicates the enhancement in the optical absorbance with the SHI irradiation of the sample and also a decrease in the band gap energy. The decrease in the energy gap is associated with the increased tailing of band edges and production of localized defect states near the Fermi level. The surface damage of the crystal was studied using atomic force microscope (AFM). The AFM image confirms that the SHI irradiated sample has strong presence of raised tails and bulges. The surface roughness of the irradiated crystal is found to be several folds larger than the non-irradiated sample.

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6. References

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