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SEM And Electrical Conductivity Studies of Pure and Potash Alum Doped KDP Crystals Grown By Gel Medium

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Abstract-- The potassium dihydrogen phosphate (KDP), one of the materials having superior nonlinear optical properties has been employed for a large range of applications. Due to this interesting properties, we made an attempt to grow pure and potash alum doped KDP crystals in various concentrations (0.002, 0.004, 0.006, 0.008 and 0.010) using gel method. The grown crystals were collected after 20 days. We get crystals with good quality and shaped. The dc electrical conductivity (resistance, capacitance and dielectric constant) values were measured at frequencies in the range of 1 KHZ and 100 HZ of pure and potash alum added crystal with a temperature range of 40 ^{0}C to 130 ^{0}C using simple two probe setup with Q band digital LCR meter present in our lab. The electrical conductivity increases with increase of temperature. The dielectric constants of metal doped KDP crystals were slightly decreased compared to pure KDP crystals. SEM study was performed to indicate the influence of dopants on surface morphology of KDP crystals.

Keywords-- *KDP, growth from gel method, electrical conductivity studies, SEM*

I. INTRODUCTION

The demand for nonlinear optical crystals with superior properties is increasing due to quantum jump in the design of nonlinear optical devices with higher performance. With the progress in crystal growth technology, materials having attractive nonlinear properties are being discovered at a rapid pace [1]. KDP crystals are widely used to control the parameters of laser such as pulse length, polarization and frequency through the first and second order electro optic effects.

New advances in the field of Material Sciences have led to several breakthroughs in the development of electronic materials [2]. Dielectrics form an interesting set of electronic materials. Potassium dihydrogen orthophosphate (KDP) KH_2PO_4, belongs to class of tetragonal crystal system and it has gained considerable interest in the field of material science on account of their extremely interesting ferroelectric, piezoelectric, pyroelectric and electro-optical and nonlinear optical properties. The excellent properties of KDP include transparency in a wide region of optical spectrum, resistance to damage by laser radiation and relatively high nonlinear efficiency. In addition, KDP crystal exhibits pyroelectric effect and used in infrared imaging. The demand for high quality large KDP single crystal increases due to its application as frequency conversion crystal in confinement fusion. The grown crystals were characterized using dielectric constant, electrical properties, SEM, for pure and Potash alum doped KDP crystals.

II. MATERIALS AND METHODS

Pure and Potash alum doped KDP single crystals are grown in sodium meta silicate gel medium using analar grade KDP and Potash alum with in concentrations of 0.002, 0.004, 0.006, 0.008 and 0.010 of dopant and sodium meta silicate (1.08g/cm^3). During the process pH was maintained at 5-6 at room temperature . Ethyl alcohol of equal volume is added over the set gel without damaging the cell surface .When the alcohol diffuses into the set gel, it reduces the solubility. This induces nucleation and the nuclei are grown into the single crystals. The crystal growth was carried out at room temperature. The growth period was about 20 days for pure and Potash alum doped KDP crystals.

Doping: Doping means adding impurity to the known pure crystal .To prepare a doped crystal a required amount of dopant solute is also mixed along with the pure solute.

An impurity can suppress, enhance or stop the growth of crystal completely. Usually it acts assure crystallographic faces. The effects depend on the pH, super saturation, impurity centralization, heat of the solution. The growth period was about 20 days. The photograph of the grown pure and Potash alum doped KDP crystals were shown in the figures

Figure 1: Photograph shows the potash alum crystals doped with KDP using test tube

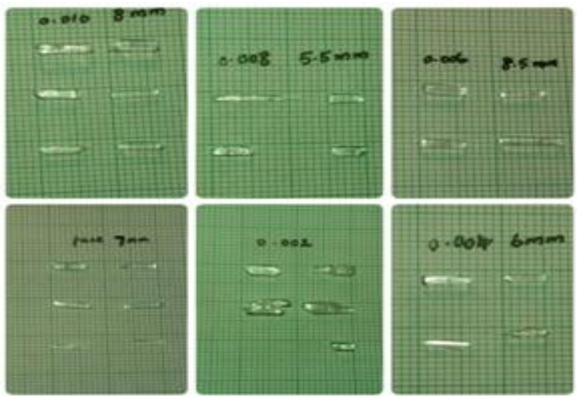


Figure 2: Photograph shows the grown potash alum crystals doped with KDP

III. RESULTS AND DISCUSSIONS

Dielectric constant and electrical conductivity studies. The various polarizations of dipoles and space charge polarization can be understood very easily by studying the dielectric properties as a function of frequency and temperature for solids. The magnitude of dielectric constant depends on the degree of polarization, charge displacement in the crystal. The dielectric constant of materials is due to the contribution of electronic, ionic, dipolar and space charge polarizations which depends on the frequencies [3]. At low frequencies, all these , polarization are active lower frequencies and high temperatures [4], in KDP crystals, many reports are available about its dielectric behavior and in our present work the measured dielectric constant values are in good agreement with the reported results [5].

Dielectric constant of a material can be measured by determining the change in the capacitance of specially designed capacitor when the dielectric is inserted between the plates of the capacitor. The capacitance, dielectric constant and electrical conductivity were measured at various frequencies (1 KHZ and 100 HZ) with a temperature range of 40^0C to 140^0 C using simple two probe setup with Q band digital LCR meter present in our lab. The capacitance and dielectric constants value of potash alum doped KDP crystals were slightly fall off in size when compared with pure KDP crystals. Lower value of dielectric constant is more in the enhancement of SHG signals. The electrical conductivity of the pure KDP and potash alum doped KDP crystals were found to be increase with increase of temperature and frequencies

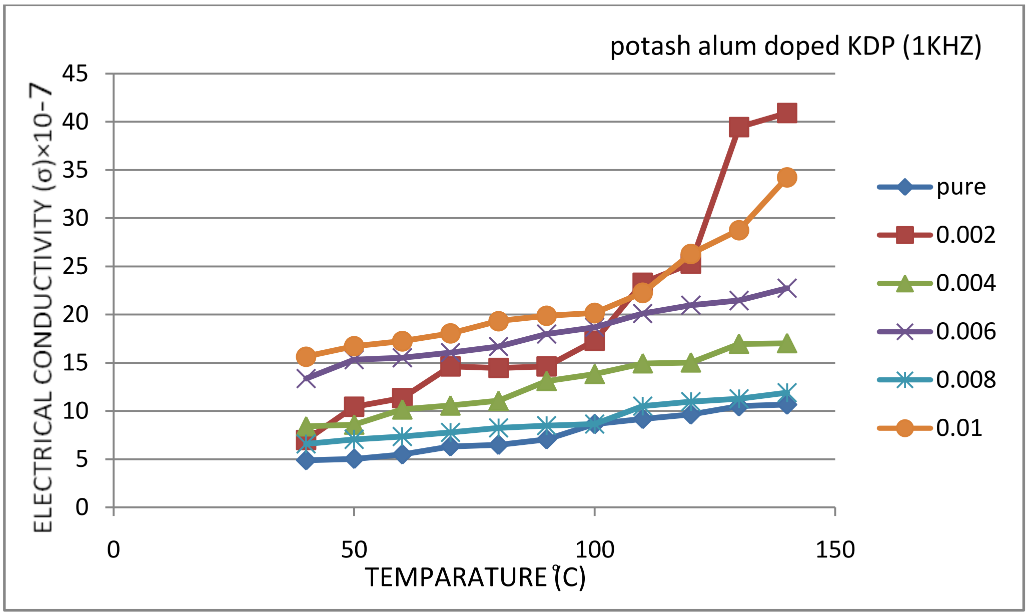


Figure 3: Variation of electrical conductivity with temperature at frequency of 1KHZ for pure and potash alum doped KDP crystals

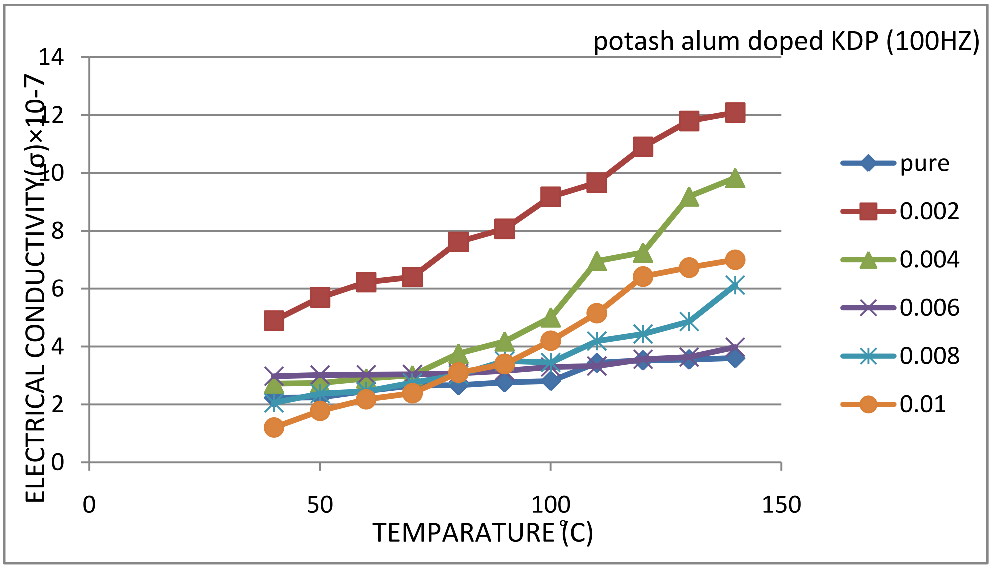
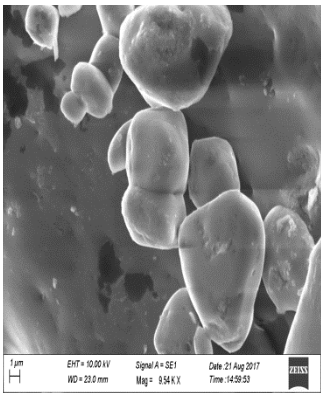


Figure 4: Variation of electrical conductivity with temperature at frequency of 100HZ for pure and potash alum doped KDP crystals

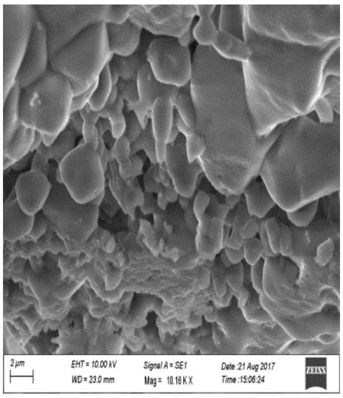
SEM Analysis

The SEM provides information relating to morphology, phase distribution and crystal structure Another important feature of the SEM is the three-dimensional appearances of specimen image. This three dimensional appearances is a direct result of the large depth of focus [6]. The SEM images for the pure and potash alum doped KDP crystals were recorded and are display in figures. The SEM images for the different concentration of samples for various magnifications were shown in figures. The SEM images of all the samples are agglomerated morphology. All the particles are uniformly distributed, however some of the particles in all the samples were found to be in a regular shapes (spherical). Also the second metal doped are more agglomerated than pure samples. The SEM images of all the concentration are lead to the formation of spherical like patterns which are good agreement.

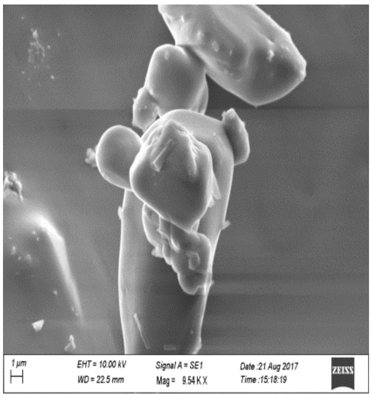
SEM images for various magnification PA1 , PA2 , PA3 , PA4 , PA5 are doped potash alum in different concentration. The figures were given below.



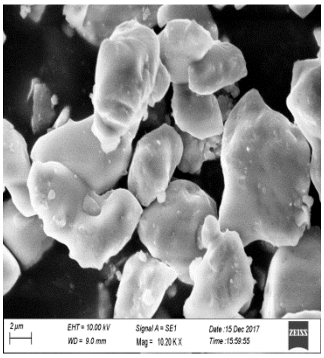
SEM PURE



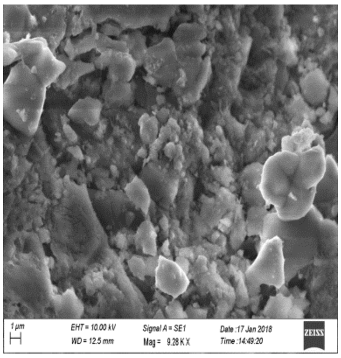
SEM PA1



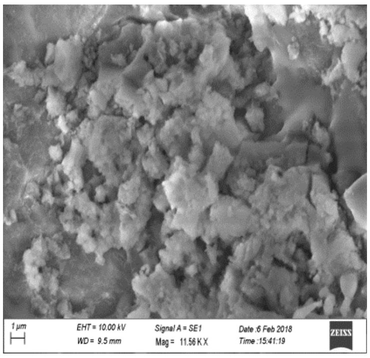
SEM PA2



SEM PA3



SEM PA4



SEM PA5

CONCLUSION

Pure KDP crystals and metal doped KDP crystals are grown by gel method. In gel growth, due to the three dimensional structures, the crystals are free from microbes. The capacitance and dielectric constant and electrical conductivity were measured at two frequencies with an average temperature range of 40°C to 140°C of pure and potash alum doped KDP crystals. The capacitance and dielectric constants of metal doped KDP crystals were slightly decreased compared to pure KDP crystals. The lower the value of dielectric constant more is the enhancement of SHG signals. The electrical conductivity (σ) of the pure KDP and potash alum doped KDP crystals was found to be increase with increase of temperature and frequencies. The SEM images of all the concentration are lead to the formation of spherical like patterns which are good agreement

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