IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 6 (June. 2018), ||V (III) || PP 54-57

An Analysis of Suitable Crystal for Electro Optic (EO) Applications by using Fuzzy soft set

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Abstract. This paper deals with the problem of selecting a best Crystal for device. Here, the Problem is solved using the concept of fuzzy soft sets.
Keywords: Crystal growth, Non linear optical materials, Row sum, Column sum, Score.

Date of Submission: 01-06-2018 Date of acceptance: 16-06-2018

I. INTRODUCTION

The ability to dominate materials can be acquired only if we possess in-depth knowledge of the science and technology. Crystal growth especially single crystals have increasingly become a vital necessity in modern technology. Crystal growth is a universal phenomenon in the field of materials. As a result crystal growth has been developed into a core discipline in material science. Crystals are the unacknowledged pillars of modern technology. Without crystals, there would be no electronic industry, no photonic industry, no fibre optic communications, which depend on materials/crystals such as semiconductors, superconductors, polarizers, transducers, radiation detectors, ultrasonic amplifiers, ferrites, magnetic garnets, solid state lasers, non-linear optic, piezo-electric, electro-optic, acousto-optic, photosensitive, refractory of different grades, crystalline films for microelectronics and computer industries.

Nonlinear optical materials

Nonlinear optical materials will be the key elements for future photonic technologies based on the fact that photons are capable of processing information with the speed of light.

Studies on the materials for nonlinear optical applications can be divided into three areas

- ❖ Discoveries of new nonlinear materials
- ❖ Growth and perfection of promising NLO crystals of desired shape and size for device applications.
- ❖ Improving the property modification of NLO crystals.

In the beginning, studies were mainly concentrated on inorganic materials such as quartz, potassium dihydrogen phosphate (KDP), lithium niobate and semi conductors such as cadmium sulphide, selenium and tellurium. At the end of 1960's the Kurtz and Perry method was introduced which allowed for the first time a rapid qualitative screening of second order NLO effect in materials. The stage was set for rapid introduction of new materials.

NLO materials are used on optical switching, frequency conversion and electro optic (EO) applications, especially in EO modulators. All these applications rely on the manifestation of the molecular hyperpolarisability of the material.

For optical applications, a NLO material should have the following characteristics [1-3].

- Wide transparency domain
- Large nonlinear figure of merit for frequency conversion
- High laser damage threshold
- Availability in large single crystal forms
- Wide phase matching angle
- Ability to process into crystal and thin film form
- Ease of fabrication

- Non toxicity and good environmental stability
- High mechanical strength and thermal stability
- Fast optical response time

Presently, inorganic and organic materials are being replaced by semi inorganics. They share the properties of both organic and inorganic materials. Recent interest is concentrated on metal complexes or organic compounds owing to their large nonlinearity. Growth of single crystals of semi–organics has been a subject of perennial concern in order to use these materials for device applications.

In mathematics, fuzzy sets are sets whose elements have degrees of membership. Fuzzy sets were introduced by LotfiZadeh and DicterKlava. In classical set theory, the membership of elements in a set is assessed in binary terms according to bivalent condition- an element either belongs or does not belong to the set. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set, this is described with the aid of the membership function valued in the real unit interval [0,1].

In fuzzy set theory, classical bivalent sets are usually called crisp sets. The notion of a fuzzy set was first introduced in 1965 by LotfiZadeh. Since then the theory has gone through remarkably rapid strides with well over 4000 papers by now in several text books and in international journals.

The basic ideas of fuzzy relations were introduced by Zadeh in 1971. Fuzzy relations are then developed by allowing the relationship between elements of two or more sets to take on an infinite number of degrees of relationship between the extremes of "completely related" and "not related". In this sense, fuzzy relations are to crisp relations as fuzzy sets are to crisp sets. fuzzy soft set theory was proposed by Molodtsov in 1999. In this paper we use fuzzy soft set to choose the best single crystals among the grown KAPT, KAPE, KAPG and KAPH for optical switching, frequency conversion and electro optic (EO) applications, especially in EO modulators..

This paper is organized as follows: Section 2 contains Preliminaries, Section 3 deals with application of fuzzy soft set. Conclusion is given in Section 4.

II. PRELIMINARIES

2.1 Row sum

The row-sum is denoted by r_i, and is calculated by using the formula

$$r_i = \sum_{j=1}^{m} C_{ij}$$

2.2 Column sum

The column-sum is denoted by C_j, and is calculated by using the formula

$$C_j = \sum_{i=1}^{m} C_{ij}$$

2.3 Score

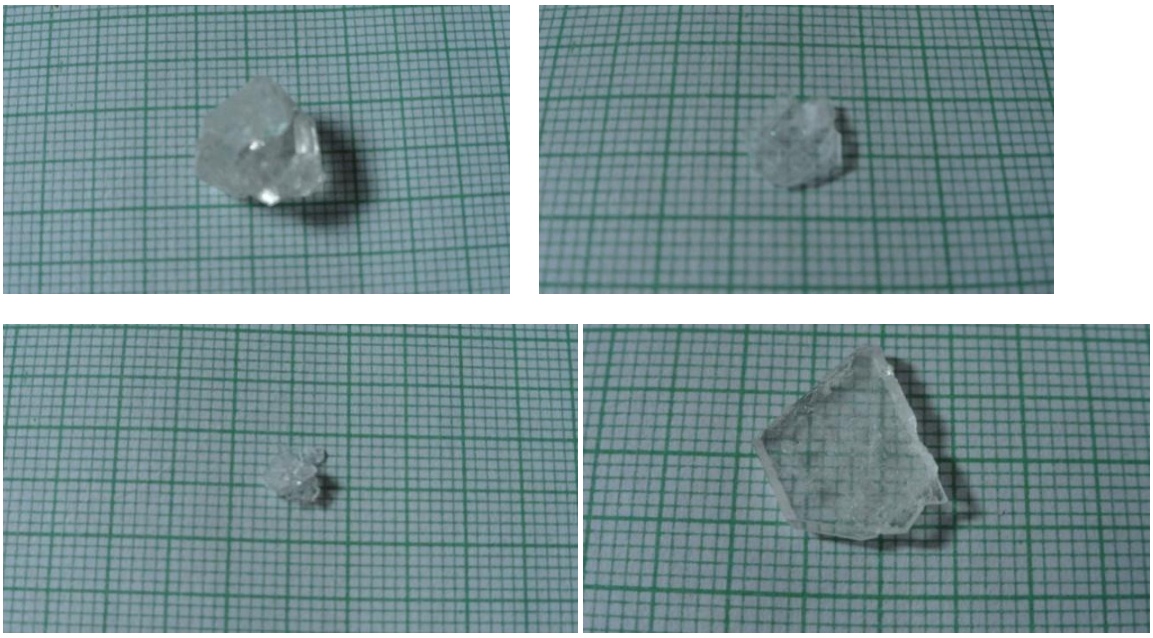
The score is denoted by S_i and is given as $S_i = r_i - C_j$. The sequence ofS_i's put in decreasing order gives the order of preference of the crystal. Then the crystal with maximum score will be the best crystal among other crystals.

2.4 Growth and characterisation of grown crystals

Pure crystallised KAP salt was used in this work. Saturated KAP solution was prepared by using double distilled water as solvent at room temperature. The prepared solution was filtered by Whatman.42 Filter paper. The saturated KAP solutions were taken in four different beakers.

2 mol % of Trytophan, EDTA, Glycine, Histidine were added as dopants. The final solution was stirred well using magnetic stirrer separately. After five days, tiny crystals were seen at the bottom of the beakers and they were used as seed crystals. Transparent and good quality seed crystals were tied with separate nylon thread and these seed crystals were placed inside the respective mother solutions for the even growth of all faces of the growing crystals.

Crystals were allowed to grow for about three to four weeks at room temperature without disturbing the vessels containing solutions and were harvested [4]. The harvested crystals of 2 mol % KAPT, KAPE, KAPG, KAPH were shown in Fig 1,2,3,4 respectively.



III. APPLICATION OF FUZZY SOFT SET

A set of all types of crystals C={c_1, c_2, c_3, c_4} (For i=1, 2, 3, 4 an alternatives c_i stands for "KAPT", "KAPE", "KAPG", "KAPH") which may be characterized by a set of all parameters P={p_1, p_2, p_3, p_4}. For j=1, 2, 3, 4 the parameters p_j stands for "1 MHZ", "Grown crystals", "Decomposition temperature of grown crystals (˚c)", "Weight loss of grown crystals" respectively.

Crystal	1 MHZ	Grown crystals	Decomposition temperature of grown crystals (˚c)	Weight loss of grown crystals
KAPT	**580.31**	**98.45**	**251**	**43**
KAPE	**621.28**	**99.92**	**280**	**42**
KAPG	**438.12**	**97.24**	**275**	**40**
KAPH	**560.29**	**98.34**	**291.6**	**42.46**

Original data of crystals (2 mol)
Table 1

The comparison table of the table 1 is

	c_1	c_2	c_3	c_4
c_1	**4**	**1**	**3**	**2**
c_2	**3**	**4**	**4**	**2**
c_3	**1**	**0**	**4**	**0**
c_4	**2**	**2**	**4**	**4**

Table 2

Next we compute the row-sum, column-sum from the table 2 and the score for each crystal is given below

	Row-sum	Column-sum	Score
c_1	10	10	0
c_2	13	7	6
c_3	5	15	-10
c_4	12	8	4

Table 3

Clearly, from table 3 the maximum score is 6, scored by the crystal (KAPE) C_2. Hence, the crystal C_2 will be the best crystal among other crystals.

IV. CONCLUSION

By using the Fuzzy Soft Set, the crystal C_2 (KAPE) ensures the suitability of the material for possible applications in lasers, where the crystals are required to withstand high temperatures. KAP crystals need larger quantity of heat energy to get heated up, so that consequent damage due to localised heating can be avoided, which enhances its prospects for applications in laser assisted devices.

When comparing the dopants with KAP, they have low ε_r values than KAP. The crystals may be considered as low ε_r values dielectric material which is gaining more importance now a day in the micro electronics industry.

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R. Sophia porchelvi "An Analysis of Suitable Crystal for Electro Optic (EO) Applications by using Fuzzy soft set." IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 6, 2018, pp. 54-57.