International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016 [ICSSCCET 2016]

ISBN	978-81-929866-6-1	**VOL**	02
Website	icssccet.org	**eMail**	icssccet@asdf.res.in
Received	25 – February – 2016	**Accepted**	10 - March – 2016
Article ID	ICSSCCET149	**eAID**	ICSSCCET.2016.149

Potential Applications of Crystal Growth Studies by SOL-GEL Method

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Abstract: *Single crystals are the pillars for the development of new generation devices to meet the demands put forth by the society. This demand requires large high quality homogeneous single crystals along with measurements on variety of properties. Hence, crystal growth and characterization of technologically important materials have evolved into thrust area of research in materials science. This review paper deals with the sol gel method for the crystal growth of nano particle size which have a great impact on industrial applications.*

Keywords: *Crystals, Growth from solution, X-ray diffraction.*

1. INTRODUCTION

Crystal growth plays an important role in modern technology. Crystals are the solids in which elementary building blocks, the atoms are arranged regularly in a space lattice with specific geometrical symmetry [1]. Crystal growth nowdays find places ranging from microelectronics, optoelectronics, medical instruments, radar systems, communication systems, defence and laser sources to the space vehicles viz., satellites [2]. Growth of large size single crystals with quality and perfection has been indentified as an important task to meet the requisities of technology development and device applications. Inorganic materials are much more matured in their applications to second order non linear than organics. Most commercial materials are inorganic especially for high power use. However, organic materials are received as being structurally more diverse and therefore are believed to have more long term promise than inorganic crystals. Growth of inorganic single crystals has been subject to perennial concern in order to use these materials for device applications [3]. A typical example is GaAs crystal, used to prevent in microwave devices, high speed digital integrated circuits, photnic and electronic devices. There has been an increasing demand for semi insulating material GaAS with the recent advances in mobile communication and digital telephony[4]. Apart from semiconductor and oxide crystals, there are several other technologically important materials like alkali halides single crystal which are used as scintillators. The emergence of NaI:Tl, the scintillation crystals have found wide applications in radiation detection. The growth of crystals can occur only if some degree of supersaturation or super cooling from the equilibrium saturated condition is the prime factor controlling he deposition process. The preset study focus on the growth of single crystals of nano particle size by sol gel method.

2. Material & Methods

Growth by Gel Method

Gel growth is an alternative technique to solution growth with controlled diffusion and the growth process is free from conversation and free from thermal strains which is common in crystal growth from melt. In this method solutions of two suitable compounds which give rise to the required insoluble crystalline substance by mere chemical reaction between them are allowed to diffuse the gel medium.

Cite this article as: O A Sridevi, R Subha. "Potential Applications of Crystal Growth Studies by SOL- GEL Method". *International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016*: 727-729. Print.

Let AX and BY are two solutions of reactants, then they react as,

$$AX + BY \longrightarrow AB + XY$$

and give to the insoluble or sparingly or soluble substance AB and also the byproduct XY being highly soluble in water. This method can be used for growing crystals from the substances having very high solubility.

3. Results and Discussions

Casados et al investigated that TiO_2 has been widely studied for photocatalytic applications; Structural characterization shows that the starting material corresponds to the crystalline anatase phase of TiO2 and upon Bi addition a phase transition to bismuth titanates and finally to bismuth oxide occur .Raman results suggest the formations of titanates for compounds with a low content of Biwhilst for higher metal contents a mixture of oxides is obtained. HRTEM results demonstrated that the prepared nanopowders are quite crystalline. Optical measurents revels that the band gap narrows from 3.2 eV to values as low as 1.4 eV. The photocatalystic activity was tested in the degradation of Malachite Green dye unde illumination using a solar simulator with good results. The raman spectra corresponding to the samples with different bismuth content, from 0.3 at% to 43.6 at%. As it can be observed, the raman spectra are different for low (< 8.6 at) and high (> 14.8 at %) bismuth content region are characterized by the vibrational modes of titanium oxide. The XRD patterns of the powders with different bismuth content. From 0.3 to 8.6 at%. The pattern corresponding to the TiO_2 powder without Bi is characterized by peaks at 2o = 25.38°.37.98° ,48.11, 54.15° ,55.03°,and 62.81. This diffractogram reveals that this sample consists of titanium dioxide in its anatase phase. This phase remains for Bi contents of 0.3, 2.7 and 3.9 at% .but as the bi content is increased smaller and broder peaks appeal.

Khan et al examined that Y_2SiO_5 is strong candidate material for host matrix for luminescent matreials ,high dielectric constant insulators and protective coatings for ceramic matrix composites such as C/ Sic ,C/C-SiC. Y_2SiO_5 ceramic powders have been synthesized by simple and reliable sol gel method using tetraethyl orthosilicate and yettrium nitrate hexahydrate $Y(NO_3)_3.6H_2O$ as precursor substances and 0.1 g of HCL as a catalyst.sol gel derived powder s were subjected to different calcination temperature. On calcining at 1250°C for 1 h, X2 from ,however, accompanied by Yttrium oxide silicate $Y_{+.67}(SiO_4)_3O$ and Y_2O_5 . The grain refinements occuring with the increase in temperatures in either polymorphs are speculated to be due to be the role of pores / inclusions or instability in the phase.

Lincy et al developed the crystal growth, structural ,thermal and optical studies of a new nonlinear coordination complex of cerium with malonic acid photoluminescence spectroscopy throws light on the optical emission properties .Excellent second harmonic generation (SHG) efficiency of the crystal was confirmed by Kurtz and power test. The thermal stability of the compound upto 100.°Cis established from the TC-DTA analysis. The optical bandgap of the material, estimated from DRS spectrum is 3.65eV. Powder XRD analysis confirms that the unit cell volume of dipotassium tartrate crystals to be 657.273 A^3. The magnetic susceptibility and magnetic moment of the crystals are found out to be 36.12x10-6 emu and 2.94 BM respectively .Thermal analysis of the crystal showed that there is no water of hydration. The endothermic peak at 285.40 °C confirms the major stage of decomposition of the sample (Mathivanan et al., 2016).

The grown crystals are characterized by X-ray diffraction, FTIR and Uv –Visible spectroscopy. X –ray diffraction reveals that the crystals belong to orthorhombic system with the cell parameters as a=10.971 A°, b=13.125A° c=5.101A ° and a=90.50^0 , β=γ=90 and space group P222.The dielectric constant of LHT decreases gradually with increasing frequency of the applied ac field (Ahmad et al., 2016). High substituted (CaZr) x Yig nanoparticals with X up to were obtained at 1080 °C. Below the melting point of Cu electrode. The average size calculated by Scherrer formula decreased from 92.4nm to 70.0nm when the substitution amount increased from o to 0.7 which was consistent with the results of TEM. The sintering temperature required to from pure garnet phase increased from690°C to 1065°C as the substitution amount x increased from 0 to 0.7 for probable homogeneity destruction by Ca^+ and Zr^+ the maximum saturation magnetization (M_s) of 29.8 emu /g was achieved at x = 0.3[10]. $ZnTio_2$ Phase precipitates by way solid reaction of Zn^{2+} with rutile crystals in TiO_2 -15 wt ZnO system . La^{3+} /Ce^{3+} -doping changes the reaction into that of Zn^{2+} with anatase crystals and decrease its forming temperature. The Ce^{3+} doping has a stronger effect that La^{3+} -doping on it[11].

Tongpeng et al examined the Sb-Bi-Te ternary compounds , with Zt values 9unitless figure of merit for semiconductor materials) as high as 1.28 were synthesized by sol-gel method using bismuth (II)acetate , antimony (III) Acetate and tellurium dioxide as precursors. The magnitude of atomic radii of Bi, Sb and Te clarity the observed increase in lattice parameters due to the substitution of larger Bi atoms in the crystal structure of Sb_2Te_3.SEM and TEM investigation revealed the morphology of all samples as aligned hexagonal nanosheet structure and high -crystallinity materials by single crystals SAD patterns. Single crystal XRD analysis revealed that the monothiourea –Cadmium sulphate Dihydrate crystallizes in orthorhombic crystal system sulphate dehydrate crystallizes in orthorhombic crystal syster. PXRD study reveled the crystalline nature. IR spectrum confirms the presence of all the expected functional groups [13].

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Reszcynska et al examined a series of $y3^{+}$, $Pr3^{+}$, $Er3^{+}$, and Eu $^{3+}$ modified TiO_2 photocatalysts were obtained via sol –gel (SG) and hydrothermal (HT) methods. The photocatalytic activity of the synthesized samples was evaluated by the degradation of phenol in aqueous solution under visible and ultraviolet light irradiations. Photocatalysts prepared by SG method possessed higher amount of RE_2O_3, the OH- groups and Ti3= species on the surface layer than powders obtained by HT method. Action spectra analysis showed that Pr^{3+} modified TiO_2 could be excited under visible light in the 420-250nm range. Furthermore photocatalysts obtained by HT method showed higher photocatalytic activity and lower intensity of luminescence emission than photocatalytst prepared by SG method. Incorporation of a small amount of RE elements into the TiO_2 structure increases the contraction of unit cell. RE ion is not able to replace Ti ion in TiO_2 lattice due to larger ionic radiuses of RE^{3+} ions than that of Ti^{4+}.All RE -TiO_2 samples prepared by the hydrothermal method have higher BET surface area and lower crystalline size compared to powers obtained by the sol-gel technique. Action spectra analysis showed that RE^{3+} modified TiO2 can be excited under visible light in the range from 420to450. The primary mechanism for the visible light sensitization was probably due of oxygen vacancies and OH- groups which appeared on the TiO surface layer.

4. Conclusions

Sol gel growth method has very good control ones growth conditions. It allows growing good quality crystals with fever defect, since the growth occurs at ambient temperatures and freezing from thermal shock. This review will provide encouraging inputs to continue the research with various dopants in the growth of single crystals will be highly useful NLO applications.

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