"SYNTHESIS OF NANOCRYSTALLINE NEW CERAMIC POLYMER COMPOSITE"

Report of the Major Research Project

submitted

to

UNIVERSITY GRANTS COMMISSION
NEW DELHI

By

DR. JAYAKUMARI ISAC

Department of Physics
C.M.S. COLLEGE, KOTTAYAM
KERALA, INDIA.

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Summary

Title of the Project:

"SYNTHESIS OF NANOCRYSTALLINE NEW CERAMIC POLYMER COMPOSITE"

1. Objectives of the project:

   (1) Preparation and characterization of ceramic powders
   (2) Fabrication of composites
   (3) Characterization of composites
   (4) Fabrication and development of new materials

2. Summary of work:

I. Synthesis and characterization of ceramic powders

Ceramics : $PbSrBaTiO_6$ and YSrBiCuO

(1) Fabrication of YSrBiCuO nano crystalline ceramic type II high-TC superconductor material by the solid state thermo chemical reaction technique and it is characterized to show good quality, homogeneity and the desired stoichiometry of the sample prepared. The results were analyzed by X-Ray Diffraction (XRD), SEM, and EDX. The particle size was determined from XRD details by Debye Scherrer formula. The SEM studies revealed that its particle size is in hundred-nanometer range. The EDX spectrum of YSBCO gave the information on the elemental composition of the material. Using Instrumental Broadening and Williamson-Hall Plot method the particle size and strain of the material were found. Line profile analysis (LPA) refers to the analysis of the shape of the peaks. Dislocation density (δ) an important material property, which gives the length of the dislocations present per unit volume (m/m3) of the sample.

(2) Nano Crystalline Ceramic lead strontium barium titanate ($PbSrBaTiO_6$) at different treating temperatures which is synthesized thermo chemically by solid state method. Such studies are not reported earlier. The X-ray diffraction (XRD) peak is broadened due to small crystallite size and strain is due to dislocations and stacking faults. The results were analyzed by X-ray diffraction (XRD), SEM, EDX. The particle size was determined from XRD details by Debye Scherrer formula. The SEM studies revealed that its particle size is in hundred nanometer range. The EDX spectrum of PSBTO gave the information on the elemental composition of the material. The particle size and strain of the material was found by Instrumental Broadening and Williamson-Hall Plot method.

(3) Band gap Energy and Optical Constants of nano Crystalline PbSrBaTiO6 Ceramics are analysed. Urbach and Band gap energies analysed with respect to different

temperatures. The optical constants such as refractive index, extinction coefficient, normal-incidence reflectivity, and absorption coefficient are found out. And the systematic variation of these quantities with temperature was noted. The dispersion of refractive index was analysed by the Wemple-DiDomenico single-oscillator method. Tunable band gaps can be obtained by varying annealing temperatures.

(4) The absorption coefficient, refractive index, energy band gap, dispersion energy and Urbach energy of nanocrystalline ceramic superconductor YSrBiCuO is analysed and calculated.

(5) **Material characterization** of superconducting nano crystalline ceramic YSrBiCuO by thermal techniques is done. TGA, DTA and DSC analysis was carried out which confirms that the composite is a good ceramic material. Each of these thermal techniques provides unique information that can be used to optimize the thermal and mechanical properties of the end product.

(6) Thermal Behaviour of Nano Crystalline Ceramic PbSrBaTiO is studied.
This includes thermo gravimetric studies and differential scanning calorimetric and infrared studies of the composites. The integral (TGA) and derivative (DTG) thermo gravimetric curves provide information about thermal stability and extent of degradation of the material. In this work TGA, DTA and DSC analysis were carried out and the result confirmed that much loss on ignition is not observed which are the characteristics of a good ceramic material. Each of these thermal techniques provides unique information that can be used to optimize the thermal and mechanical properties of the end product. IR Spectroscopy finds wide spread application in quantitative and qualitative analysis.

(7) IR data of these two samples taken, analysis done and using software detailed studies are continuing. M-O bands and Octahedral vibrations related to the ceramics were observed.

(8) Dielectric properties and impedance analysis of the ceramics analysed/calculated by LCR Impedance analyzer. Both materials have high dielectric values. The dielectric constant of the composites increases with increase in temperature. Dielectric measurements were carried to analyse the dielectric constant and dielectric loss at different frequencies and different temperatures. Results show that dielectric constant, as well as dielectric loss, decreases with increasing frequency and then becomes frequency independent at high frequencies. AC conductivity increases with frequency. The frequency dependence of dielectric constant of both low and high frequency plots was explained.

2. Fabrication, Characterization of the Polymer ceramic composites

In this section the authors describes a method for the preparation of **YSrBiCuO and $PbSrBaTiO_6$** - super conducting ceramic powder materials based on pre-calcinations of oxides and the prepared powder was mixed with polymer material to form a new polymer composite in different compositions. The results were analyzed by X-ray

diffraction (XRD), SEM, EDX. The particle size was determined from XRD details of the ceramic powder material, by Debye Scherrer formula. The SEM studies revealed that its particle size is in hundred nanometer range. The EDX spectrum gave the information on the elemental composition of the material. Young's modulus of the prepared polymer composites of different compositions are calculated by different equations in theoretical modeling.

The mechanical properties such as Young's modulus of two-phase composites were calculated using different equations in theoretical modeling and plotted graphically.

(1) **Usin**g A brabender plasticorder Polypropylene mixed with ceramics (two different samples: PbSrBaT and YSrBiCuO) , fabricated the corresponding polymer ceramic composite.
(2) XRD of 10%,20%, 30% and 40% ceramic mixed polymer composites were taken and analyzed. Theoretical modelling considered, calculated corresponding values and confirmed the values.
(3) Tensile strength studied and analysed using UTM.
(4) Optical properties analysed.
(5) Morphology Evaluation also is finished.

3. Deliverables

1. Ceramic-polymer composites for electronic, optical and medical applications
2. Publication of research papers in international Journals
3. Trained manpower in the area of ceramic polymer composites.

4. Application:

Electronic technologies that allow a reduction in size, weight, cost of materials and simultaneously improving functionality and performance are highly desired for military and commercial applications, including telecommunications, network systems, automotive and computer electronic devices. Development of electronic devices working at high operating frequencies, such as fast computers, cellular phones, etc. require a new high –dielectric constant material that combine good dielectric properties with both mechanical strength and ease of processing. In short high –K materials are required for making embedded capacitors for integrated electronic devices. Ceramic polymer composites which are dealing in this project are suitable in these cases.

A sound understanding of the properties of the sample shows that YSBCO and PSBTO will definitely have a future in power electronics and microelectronics.

5. ***Six International Publications related to this Topic.***

Sl.no	Author	Article/Paper	Name of the Journal	Year
1.	*Jayakumari Isac, Anusha Mony, etc.*	*Fabrication and Analysis of Nanocrystalline Superconductor YSrBiCuO at Different Calcination Temperatures*	*International Journal of Science and Research (IJSR)*	*Volume 3 Issue 12, December 2014, ISSN (Online): 2319-7064*
2.	*Jayakumari Isac, Anusha Mony, etc.*	*Structural and morphological studies of nano crystalline ceramic $PbSrBaTiO_6$ at different treating temperatures*	*Journal of Advances in Chemistry*	*Vol. 10, No. 10, 3303, December 17, 2014*
3.	*Jayakumari Isac, Anusha Mony, etc.*	*Thermal Behaviour of Nano Crystalline Ceramic PbSrBaTiO*	*IJISET-International Journal of Innovative Science, Engineering & Technology*	*Vol. 1 Issue 10, December 2014. www.ijiset.com*
4.	*Jayakumari Isac, Anusha Mony, etc*	*Material Characterization of Superconducting Nano Crystalline Ceramic YSrBiCuO by Thermal Techniques*	*Journal of Advances in Physics*	*Vol.7, No. 1, 1352, January 03, 2014*
5.	*Jayakumari Isac, Anusha Mony, etc*	*Bandgap Energy and Optical Constants of Nano Crystalline $PbSrBaTiO_6$ Ceramics*	*International Journal of Science and Research (IJSR)*	*Volume 3 Issue 12, December 2014*
6.	*Jayakumari Isac, Anusha Mony, etc*	*Investigation of the Absorption Coefficient, Refractive index, Energy Band Gap, Dispersion Energy and Urbach Energy of Nanocrystalline Ceramic Superconductor YSrBiCuO*	*International Journal of Recent Scientific Research*	*Vol. 6, Issue, 1, pp.2438-2444, January, 2015*

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