

**UNIVERSITY GRANTS COMMISSION  
BAHADUR SHAH ZAFAR MARG  
NEW DELHI – 110 002**

**PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING  
THE FINAL REPORT OF THE WORK DONE ON THE PROJECT**

1. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR: **Dr. Aarti S. Iyer Muley**
2. NAME AND ADDRESS OF THE INSTITUTION: **SIES College of Arts Science & Commerce, Sion (West), Mumbai-400 022.**
3. UGC APPROVAL NO. AND DATE : F. : 47-442/12 (WRO)
4. DATE OF IMPLEMENTATION: August-2013
5. TENURE OF THE PROJECT: 2 Years
6. TOTAL GRANT ALLOCATED: Rs. 1,75,000/-
7. TOTAL GRANT RECEIVED: Rs. 1,42,500/-
8. FINAL EXPENDITURE: Rs. 1,42,500/-
9. TITLE OF THE PROJECT: Nano Phosphor for Solar Energy Conversion
10. **OBJECTIVES OF THE PROJECT:**

Solar energy is unquestionably the most promising energy resource being inexhaustible and pollution-free. The commercial photovoltaic solar cells are fabricated with crystalline silicon (c-Si) with a band gap of 1.12 eV. However, mismatch between the incident solar spectrum and spectral response of solar cells limits the cell efficiency to 29 %. Though c-Si solar cells are most successfully commercialized, dye sensitized solar cells (DSSC) are also expected to compete. Several commercial providers are promising availability of DSSCs in the near future . In both these types, nanophosphors can play a major role for improving the efficiency. In order to meet the long run demand and energy-saving consideration, solar energy has become most promising energy resource. The capacity of photovoltaic cells to convert sunlight into electricity makes them prime candidates for this task. However, thermalization of charge carriers generated by the absorption of high-energy photons reduce the conversion efficiency of solar cell greatly. At present the contribution of photovoltaic energy is limited due to its relatively high cost per kilowatt-hour. A reduction in price may be achieved by either lowering the production cost or increasing the conversion efficiency. State-of-the-art commercial crystalline Si (c - Si) solar cells dominate the market and have energy efficiencies around 15%. The main objective of the work

- To synthesize the solar phosphor in the form of fine powders of various sizes in nano form.
- To Identify materials which will absorb near UV/ blue light (300-450 nm) and convert it to the near Infra Red (NIR), regions .
- To synthesize the identified phosphors on 100 g batch scale.

- Detailed characterization of the identified phosphors.

#### 11. WHETHER OBJECTIVES WERE ACHIEVED: Yes

The phosphor for visible to Infrared conversion in Si- Solar cell have identified. Bismuth ( $\text{Bi}^{3+}$ ) is known as efficient luminescent dopant. If it is doped with  $\text{Yb}^{3+}$  in the host material  $\text{Y}_2\text{O}_3$  :Bi:Yb then  $\text{Bi}^{3+}$  gives intense emission in the green region and Yb gives the emission in the Near Infra Red (NIR) region at 1030nm. The energy transfer process in this phosphor has observed successfully. The phosphors  $\text{CaF}_2$  and  $\text{SrF}_2$  doped with cerium and co doped with Yb are successfully prepared in nano form. The size of the particle is achieved from 200nm to 700nm. The emission of Yb is observed at 930nm.

#### 12. ACHIEVEMENTS FROM THE PROJECT:

The different inorganic and organic phosphors are prepared using methods. Cerium Sulphate was prepared using co precipitation method. The particle size is reduced to 500nm in cerium sulphate.  $\text{CaF}_2$ :Ce and  $\text{SrF}_2$ :Ce prepared using controlled precipitation shows a strong red shift in emission. The emission shifted from 366nm to 420nm. When it is co doped with Yb, then the emission observed at 930nm. The successful energy transfer is observed in  $\text{Y}_2\text{O}_3$  :Bi:Yb. The organic phosphor i.e anthracene and it's derivatives 9-chloro acridine and Anthracene-9-ylmethylacetate are prepared in polymer matrix.

#### 13. SUMMARY OF THE FINDINGS:

Energy loss has been occurred when solar light has converted into electricity due to the spectral mismatch. The promising way is to use the down conversion phosphor material. In this work we are able to prepared a phosphor doped with Bi:Yb and with Ce:Yb. The reduction in particle size plays an important role here.  $\text{Y}_2\text{O}_3$  phosphor prepared by oxylate method shows the enhanced green emission at 490nm when it is excited with 328nm when doped with  $\text{Bi}^{3+}$ . The phosphor doped with  $\text{Y}_2\text{O}_3$ : Bi: Yb shows the emission at 1030nm. With the excitation of 327nm and 370nm the emission of  $\text{Yb}^{3+}$  occurred. Hence  $\text{Bi}^{3+}$  which absorbs energy can be transferred to  $\text{Yb}^{3+}$ . The excitation bands of  $\text{Y}_2\text{O}_3$ :Bi and  $\text{Y}_2\text{O}_3$ :Bi:Yb matches well and hence the process of energy transfer has been occurred. Hence this phosphor is considered as a good candidate for quantum cutting.

$\text{CaF}_2$  and  $\text{SrF}_2$  doped with the cerium are prepared with the control precipitation method and the results are compared with the bulk material. A strong red shift is observed in both the samples due to reduction in particle size. The samples prepared by co precipitation method. In

CaF<sub>2</sub> a emission is observed at 410nm while in SrF<sub>2</sub> it is observed at 430 nm. If these materials is co doped with Yb i.e CaF<sub>2</sub>:Ce:Yb and SrF<sub>2</sub>: Ce:Yb then it gives the emission at 930nm. This shows the energy transfer process is also observed in these phosphors.

The various phases in Cerrous Sulphate is also identified using simple method. The cerrous sulphate prepared by control precipitation method is compared with the bulk. Ce<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> in 0.9H<sub>2</sub>O hexagonal phase is observed by controlling the concentration of precursor and precipitation rate. The significant change in PL spectra are observed in hexagonal, orthorhombic and anhydrous phase of Ce<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>. The photoluminescence in this phase shows the emission at 344nm with the shoulder around 366nm. The excitation spectra are observed around 263nm. This is different from Ce<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>.8H<sub>2</sub>O phase. When heated at various temperatures the shoulder will be more pronounced and at 600<sup>0</sup>C it doesn't shows any intensity.

This difference in spectra should be explained on the basis of difference in the particle size of the sample. Since the particle size of S<sub>2</sub> is small (<10micron), the particles are less stable. On heating they quickly react with oxygen and therefore the exotherm are appearing at lower temperature. When S<sub>2</sub> is heated at 600<sup>0</sup>C it reacts with oxygen more vigorously and gets converted into form in which the valency of Ce is 4+ which is non luminescent form. Such conversion due to Auger loss is well explained by Blasse in CeF<sub>3</sub> compound.

The anthracene and it's derivative 9-chloro acridine and Anthracene-9-ylmethylacetate have prepared in Poly vinyl alcohol(PVOH). Their photoluminescence properties have studied. The pure anthracene has an emission at 424 and 443nm. The intense peak is observed at 465nm and shoulder at 407nm. The derivatives of anthracene Anthracene-9-ylmethylacetate shows an emission around 440nm for the excitation at 393nm and 9-chloro acridine shows emission around 360nm for the excitation at 290nm. The major problem of this organic material is it's stability. The composites prepared in the medium of PVOH are more stable. Anthracene and its derivatives prepared in PVOH give enhanced emission even at low concentration comparable to pure anthracene. The PVOH layer arrests the particles and protects them from the atmospheric moisture and hence stability of the molecules increases.

#### 14. CONTRIBUTION TO THE SOCIETY .....

Today, millions of people around the world do not have access to regular electricity and majority of them are found living in rural areas of India .Through this research study I'd like to develop an applicable knowledge in the field of "luminescence phosphor particle and its application in PV solar cell". This knowledge will be useful for socio-economic advancement India. Being an academican and researcher I would like to impart the knowledge of green environment, to the students and to the betterment of society. This also includes how to use the non conventional energy sources to reduce the cost of energy. This also protects the environment globally.

#### 15. WHETHER ANY PH.D. ENROLLED/PRODUCED: NIL OUT OF THE PROJECT

#### 16. NO. OF PUBLICATIONS OUT OF THE PROJECT:

1. A Vyas, NA Mirgane, SV Moharil, **AI Muley**," Photoluminescence in Anthracene and it's derivatives", **American Institute of Physics Conference Proceeding 1728**, 020059 (2016); doi: 10.1063/1.4946110.
2. **Aarti A. Muley**, C.V. Venkatakrisnan,K. Venkatramanan, S.V. Moharil "National Seminar on Frontier Areas of Spectrophysics 2103(NASFAS2013)"-"Photoluminescence in orthorhombic, Hexagonal and Anhydrous Phases of cerrousSulphate". Pg No.:14-17. ISBN: 978-81-925639-4-7. organized by SCSVMV university on 19<sup>th</sup> -20<sup>th</sup> Dec. 2013, Kanchipuram, Tamilnadu.

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