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Synthesis and Characterization of High-Performance Solar Cell

A. Verma[1]*, A.K. Diwakar[2], R.P. Patel[3]

[1,2,3] Department of Physics, Kalinga University, Atal Nagar, Raipur (C.G.), India

Corresponding Author: alokeverma1785@gmail.com

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Abstract— High-performance solar-cell is designed for lead-free perovskite materials, synthesis of using for the organometallic halides. The perovskite materials having a high-efficiency charge carrier and identified low-cost materials based commercial photo-voltaic cell. It is an unusually breakthrough of the drawback of high-efficiency photo-voltaic solar-cell because in this solar-cell replaced harmful lead using various perovskite materials like (Sn^{2+}, Ge^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cu^{2+}, Fe^{2+}, Pd^{2+}, and Eu^{2+}). We predict the structure and optical properties of perovskite solar-cell based on Ge and Sn solid solutions, $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ ($0 \leq x \leq 1$). This material is having the band gaps from 1.3 to 2.0 eV, and it is suitable for an optoelectronic application's range, from single junction devices and top cells for placement to light-emitting layer. The power efficiency of lead-free perovskite solar-cell (LFPSCs) is more than 27%. Which has ABO_3 type orthorhombic crystal structure and successfully examine its structure using X-ray diffraction (XRD) technology. In this research, we synthesis successfully lead-free perovskite solar-cell (LFPSCs).

Keywords— Perovskite material; Solar-cell; X-ray diffraction (XRD); Halides; Inorganic cation and anion; Methyl-ammonium.

I. INTRODUCTION

Last few years, in this field lots of work and developing many new types of solar cell material. Lead is a very harmful element for our environment. So we work on this field and remove to lead in solar cell and developing new type solar cell synthesis from Sn and Ge. It's a fourth generation solar cell full fill our requirement of energy and more efficient from the traditional solar cell. Perovskites material having lots of physical property one of the most important properties of these materials easily shows the PV properties. In this research we use orgenomatlic perovskite solar cell material $CH_3NH_3Si_{(1-x)}Ge_xI_3$ (x = 0.1, 0.2, 0.3, 0.4, 0.5) [1].This solar cell performance high efficient solar cell and having a traditional perovskite structure. Remarkable work on thin film fabrication such as thermal co-evaporation in high vacuum, sequential deposition, vapor assisted solution process (VASP), chemical vapor deposition, solvent engineering, intermolecular exchange, has led to this extreme development [2]. The lead-free perovskite materials for solar cell application reported so far, tin-based perovskites which have the chemical formula of $ASnX_3$ where A can be Ge, methylammonium (MA) and X can be I, Br, Cl or F, are the most promising substitutions since Sn and Pb both belong to group 14 of the periodic table and thus are predictable to possess comparable physical and chemical properties. As a result, the nature of the chemical bonding becomes more covalent in the case of $ASnI_3$ systems because of the relatively larger degree of orbital overlap in the shorter Sn-I bond compared to the Pb-I bond. The consequences of this subtle difference in chemical bonding have a strong impact on the semiconducting properties of the materials.

II. EXPERIMENTAL METHOD

First, of make 4 mm TiO_2 thin layer using by sole-gel process and vapor deposition of a compact layer of TiO_2 using annealing at 450°C for 30 minutes, and after then cooled at room temperature gradually. After the TiO_2 layer prepared $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ active layer. The synthesis of $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ using equimolar quantities of CH_3NH_3I, SnI_2 and GeI_2 concentration of 45 wt% was dissolved in a mixed solvent of DMF and DMSO-GBL with a ratio of 3.5:7. The schematic of the active layer deposition is shown in Fig. 2 [3]. The precursor solutions were spin coated onto TiO2 coated substrates to form a dark-brown tin perovskite layer [4]. Because of the $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ gradually decomposed in the air, all the preparation of $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ films were performed in the nitrogen glove box to avoid hydrolysis and oxidation of tin perovskite layer in contact with rotating air [4]. Now successfully prepared lead-free perovskites solar cell (LFPSCs) using the organometallic compound.

III. CHARACTERIZATION

The characterization of the solar cell basically shows its efficiency on different parameters. The morphologies of the $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ layer and the fabricated perovskite solar cells were examined using a high-resolution scanning electron microscope and a focused ion beam assisted SEM [5]. The absorbance of the $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ perovskite active layer was analyzed using a UV/Vis spectrometer in the wavelength range from 500 to 900 nm. Photocurrent density-voltage curves were recorded using a solar simulator equipped with a 450 W xenon [6]. An aperture mask was used while measuring the devices in reverse scan mode at 200 ms scan rate. The EQE was measured using a specially designed EQE system, wherein a 75 W xenon lamp was used as a light source to generate a monochromatic beam [7].

IV. RESULTS AND DISCUSSION

Successfully examine of the XRD pattern of $CH_3NH_3Sn_{(1-x)}Ge_xI_3$. The straight XRD measurement for all examined $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ shows that their (110) peak strengths have no important diff erence and the order of 40% > 20% > 10% > 0%, which is not steady with the PCE result. We also correlate the nanostructural of the films to the crystal orientation. For the perovskite films with internal pore network, the crystallites oriented to the out-of-plane direction dominate [8]. No crystallites with the in-plane coordination were speciously examine. The condensed perovskite films through surface fractal structural have the crystallites with outside of plane as well as inside plane orientations. Successfully examine of current-density ($mAcm^{-2}$) Vs applied bias voltage (V) curves of the best execution solution-processed (blue lines, triangles) and vapour-deposited (orange lines, circles) lead-free perovskite solar cell LFPSCs [9].

V. CONCLUSION

For the experimental material synthesis using sol-gel and vapour deposition method, and successfully design LFPSCs. LFPSCs material characteristics like XRD, UV/Vis and Current-density ($mAcm^{-2}$) Vs applied bias voltage (V) curves successfully examine. Finally, we are success to improve efficiency of solar-cell and successfully examine and design of LFPSCs.

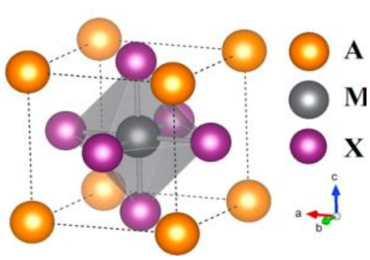

Figure 1 Perovskites structure of AMX_3 where A- Ge and CH_3NH_3, M- Sn, X- I

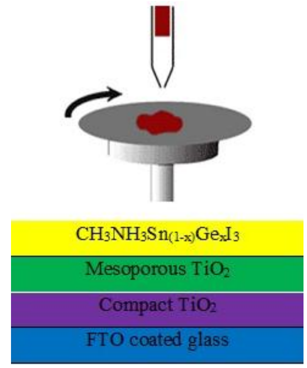

Figure 2 The schematics of the active layer of $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ layer deposition.

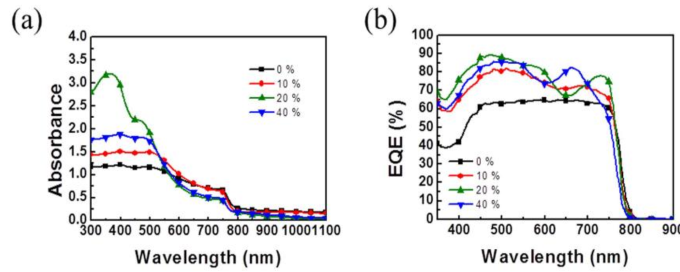

Figure 3 UV – absorption spectra of lead-free perovskite solar cell (LFPSCs)

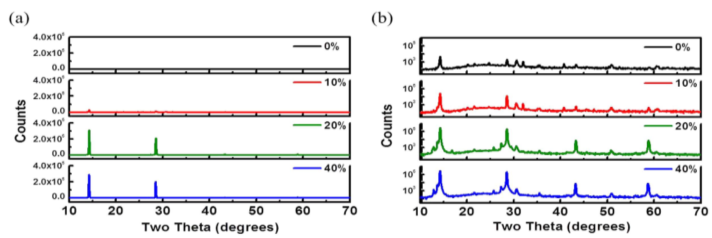

Figure 4 XRD patterns (a) in linear and (b) in logarithmic scale of the $CH_3NH_3Sn_{(1-x)}Ge_xI_3$ prepared with 0, 10, 20 and 40% of iodide, respectively

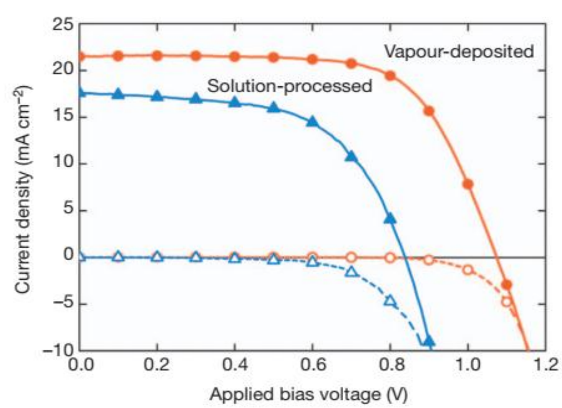

Figure 5 Current-density ($mAcm^{-2}$) Vs applied bias voltage (V) curves of the best execution solution-processed (blue lines, triangles) and vapour-deposited (orange lines, circles) lead-free perovskite solar cell LFPSCs

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AUTHORS PROFILE

Mr. A Verma, M. Sc., M. Phil., and Ph. D. (Research Scholar) Physics from Kalinga University, Raipur. He has published more than 07 research papers in reputed international journals and conferences and it's also available online. His main research work focuses on solar cell.

Dr. A K Diwakar, Ph.D. Physics from Pt. Ravishnkar Shukla University, Raipur. He is currently working as Associate Professor in Department of Physics from Kalinga University, Raipur since 2018. He has published more than 15 research papers in reputed international journals including Thomson Reuters (SCI & Web of Science) and conferences and it's also available online. His research area on Astrophysics and Solar Cell. He has 11 years of teaching experience and research experience.

Dr. R P Patel, Ph.D. Physics from Rani Durgavati University, Jabalpur. He is currently working as Professor and HOD in Department of Physics from Kalinga University, Raipur since 2018. He has published more than 26 research papers in reputed international journals including Thomson Reuters (SCI & Web of Science) and conferences and it's also available online. His research area on Luminescence and Solar Cell. He has 20 years of teaching experience and research experience. Hs is also member of various journals of editorial board and reviewer.

