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GUANIDINIUM LEAD BROMIDE THIN FILM FOR PEROVSKITE ABSORBER LAYER

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Abstract: Guanidinium is one of the materials which are used in the perovskite solar cells and light emitting diodes to induce stability and increase the efficiency. Lead halide perovskite solar cells have achieved an enormous efficiency over a decade. In order to that we have used Guanidinium Bromide as the component with Lead bromide in an equal proportion to synthesize Guanidinium Lead Bromide ($GAPbBr_3$) solution. The films were coated on the glass substrates using Drop – casting method and the characteristics were studied. The thickness calculated using surface profoliometer is 3. 2632µm.

Index terms: Perovskite, Guanidinium, solar cell, LED.

I. INTRODUCTION:

Thin film solar cells has achieved enormous efficiency in the past few years in order to eliminate the production cost of the silicon wafers which was a boon in the production of Photovoltaic modules. In order to replace the wafers, a semiconducting material was coated as a thin film layer on the substrate forming junctions. In that case perovskite solar cell is considered to be one of the thin film solar cells which have achieved its remarkable way in this short decade because of low manufacturing costs and high efficiency. In just a decade the perovskite solar cells has marked a remarkable efficiency due to the metal halide perovskite materials. The following factors which exhibits this materials as a most promising one includes, low excitation binding energy, fast carrier diffusion speed, long diffusion length, and high absorption co – efficient.

The material possesses large dielectric constant and electrons and holes can be effectively transmitted and collected(1). In 2009, Japanese Scientists Kojima et.al introduced organic metal halide perovskites as a light absorber which was similar to that of the Dye – Sensitized solar cells and achieved a conversion efficiency of about 3.8% (2). In 2012, Kim et.al for the first time reported the perovskite solar cell with a conversion efficiency of about 9.7% (3). National Renewable Energy Laboratory introduced an efficiency chart containing the highest solar cell efficiencies in that Perovskite solar cells became an emerging photovoltaic technology with a record of conversion efficiency of 14.1% in the year 2014 [(4)]. Then it has been attained an increasing efficiency in the past 10 years tremendously as 25.5% [(5)]. Similarly the perovskite Si tandem has exceeded the efficiency of 29.5% [(6)].

Perovskite materials are also suitable for making Light Emitting Diode due to their high colour purity, tuneable bandgap and high and balanced carrier mobility for both electrons and holes. Perovskite materials for LED applications have a longer history than solar cells[(7).] In 1994, researchers investigated low dimensional perovskite materials and were able to make bright LED's[(8).] In 1999, researchers demonstrated an Perovskite LED with very low efficiency at room temperature[(9).] In 2014, the performances of perovskite solar cells lead to the increase in the case of electroluminescence at room temperature [(10)].

II. MATERIAL AND METHOD:

Perovskite materials as already considered being the emerging materials specifically metal halide perovskites has played a major role. Since researches are fully on the side of Methyl ammonium lead bromide scientists and researchers are trying to increase the efficiency by adding other materials as cation.

Guanidine based functional groups occur in many branches such as Neutral (Guanidine), Cation (Guanidinium) and Anionic (Guanidinate)[(11)]. Guanidinium is one of such materials which increases the stability and performance of Methyl ammonium Lead iodide by adding as a cation. Guanidinium have been reported to yield more stable perovskites and in particular GA – based cation perovskite has been absorbed as an attractive absorber for devices with high efficiency as well as superior stability [(12)].

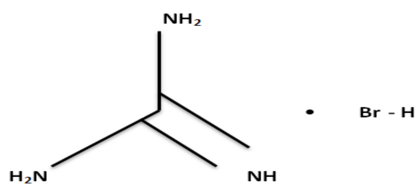

Figure1.Structure of GABr

Guanidinium bromide is purely an organic cation and for making the precursor solution the Guanidinium Bromide (GABr) is purchased from Sigma - Aldrich and Lead Bromide ($PbBr_2$) from Oxford lab fine chemical, Maharashtra, India. The solvent distilled water was purchased from Nice Chemicals, Kerala, India.

Synthesis of precursor solution:

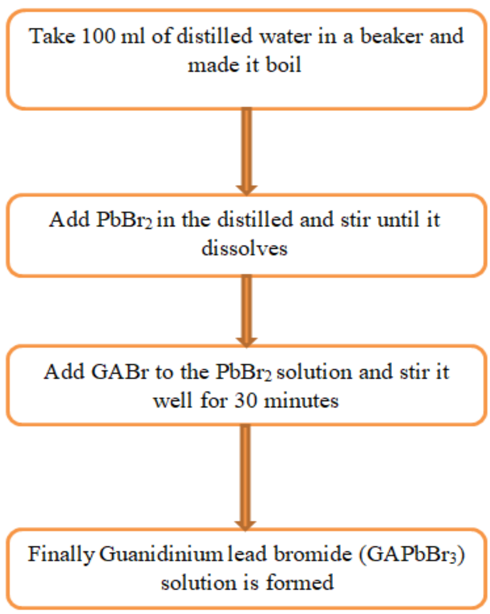

Figure2. Synthesis of precursor solution

The precursor solution was made by adding 100 ml of distilled water into the beaker and made it boil till it reaches the boiling point. GABr and $PbBr_2$

were taken in the ratio 1:1. After the distilled water reaching its boiling point $PbBr_2$ is added and made stir until it dissolves. Finally add GABr in the lead bromide solution and stir well for about 30 minutes and finally the precursor solution is prepared for coating.

The glass plate is cleaned by using distilled water two times and made to heat till it evaporates. Then finally it is cleaned by using acetone. The general procedure of this method is shown in the above figure 4. The prepared solution is taken in a beaker. The glass rod is dipped in the solution and then placed in the cleaned glass substrate in the form of drops. The drops are placed near by another drop so that the solution spreads equally on the glass substrate. After that the coated glass plate is made to evaporate.

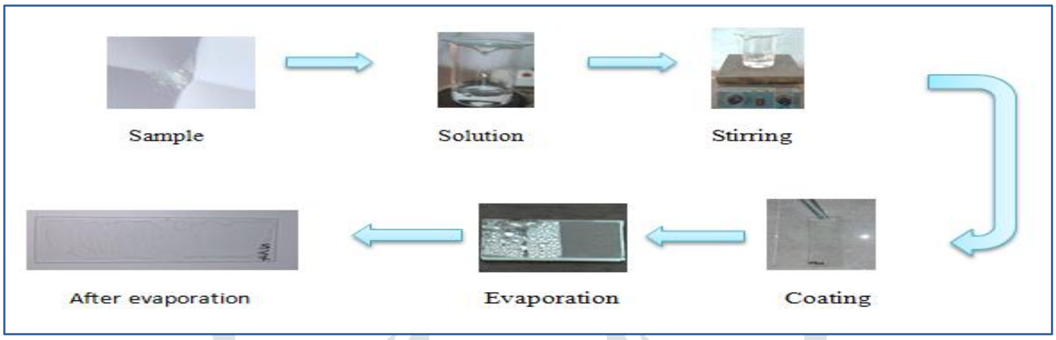

Figure4. Block diagram of $GAPbBr_3$ coating

RESULTS AND DISCUSSION

Fourier transform infrared spectroscopy

The Figure 5 shows the FTIR spectrum for the $GAPbBr_3$ thin film. The peak at 2121.43^{cm-1} is the weakest peak which is attained at C≡C stretching which belongs to alkyne groups. Three medium peaks were obtained in which 1678.61^{cm-1} belongs to C= N stretching of imine/oxime compound class. The bending vibrations of N- H and C- H molecules were obtained at 1601.70^{cm-1} and 1386.70^{cm-1} which belongs to amine and alkene groups. Then six strong peaks were obtained. The bending vibrations of C = C molecules were obtained at 872.77^{cm-1} belongs to alkene class. 813.56 $^{cm-1}$, 684.44 $^{cm-1}$, 522.55 $^{cm-1}$ peaks were absorbed which belongs to stretching C- Cl, C – Br, C- I groups.

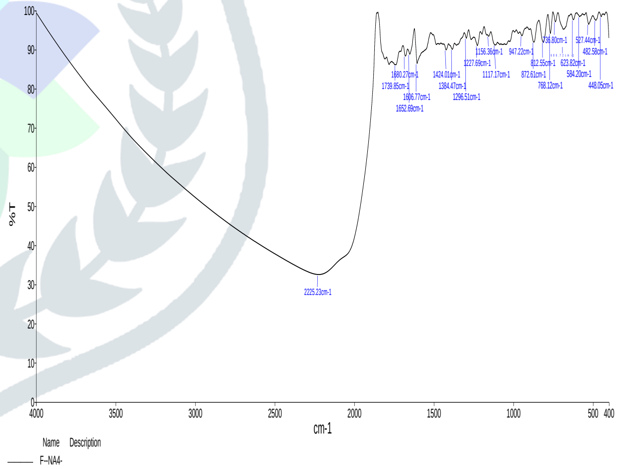

Figure5. FTIR Graph for $GAPbBr_3$ thin film.

UV – Visible Spectroscopy

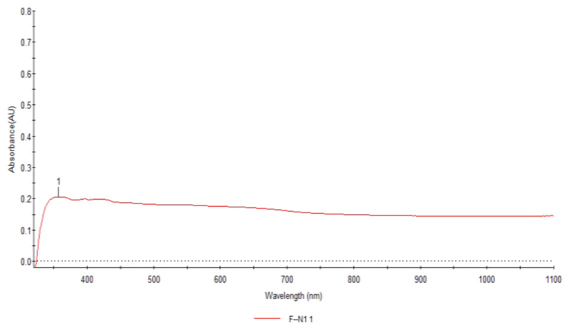

Figure 6(a). Absorption spectrum of UV - VISIBLE Spectroscopy

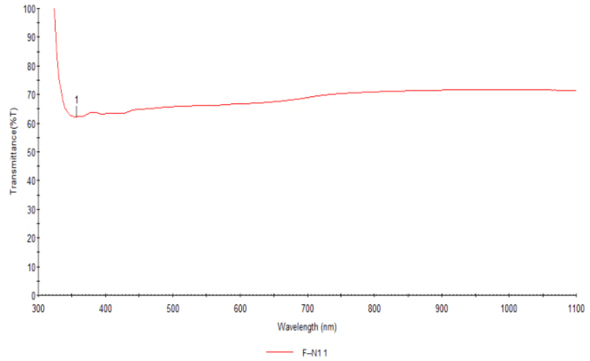

Figure 6(b). Transmission spectrum of UV – VISIBLE spectroscopy

The optical properties are studied using uv – visible spectroscopy. The figure 6(a) and 6(b) shows the absorbance and transmission peaks of the $GAPbBr_3$ for perovskite solar cells. The absorbance and transmittance measurement ranges from 200 – 800nm. The thin film has low absorption and high transmittance within this region. The optical transmission of thin film was found to be at 356.70 nm in wavelength. The bandgap calculated is found to be 3.48 eV respectively.

Photoluminescence Spectroscopy

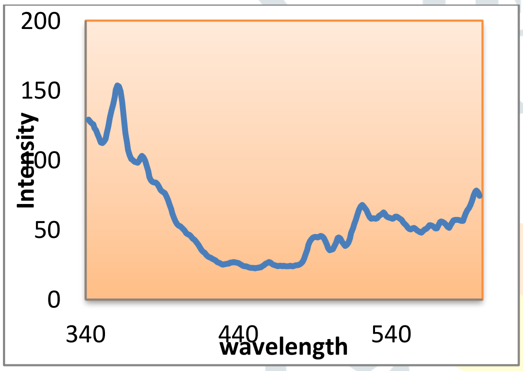

Figure7. Photoluminescence spectrum for $GAPbBr_3$ thin film.

The above figure 7 shows the photoluminescence spectrum of $GAPbBr_3$ for perovskite solar cells. The excited wavelengths were absorbed at peaks 360 nm, 369.07 nm, 504.01nm, 518.95 nm, 571.02 nm. The maximum intensity of 150.56 was at the range of 360 nm.

Scanning electron microscope

The morphological studies are analysed by using scanning electron microscope. The instrument used for studies of thin film samples is EVO – 18 CARL ZEISS. The SEM images are taken under different magnifications in the range of 1µm, 2µm, 10 µm, 20 µm, 200 nm. From the images below 8(A), (B), (C), (D), (E) we may able to identify that the structure of $GAPbBr_3$ is found to be in porous structure. The particle of the size is found to be in the range of 376.6 nm, 492.1 nm and 525.3 nm.

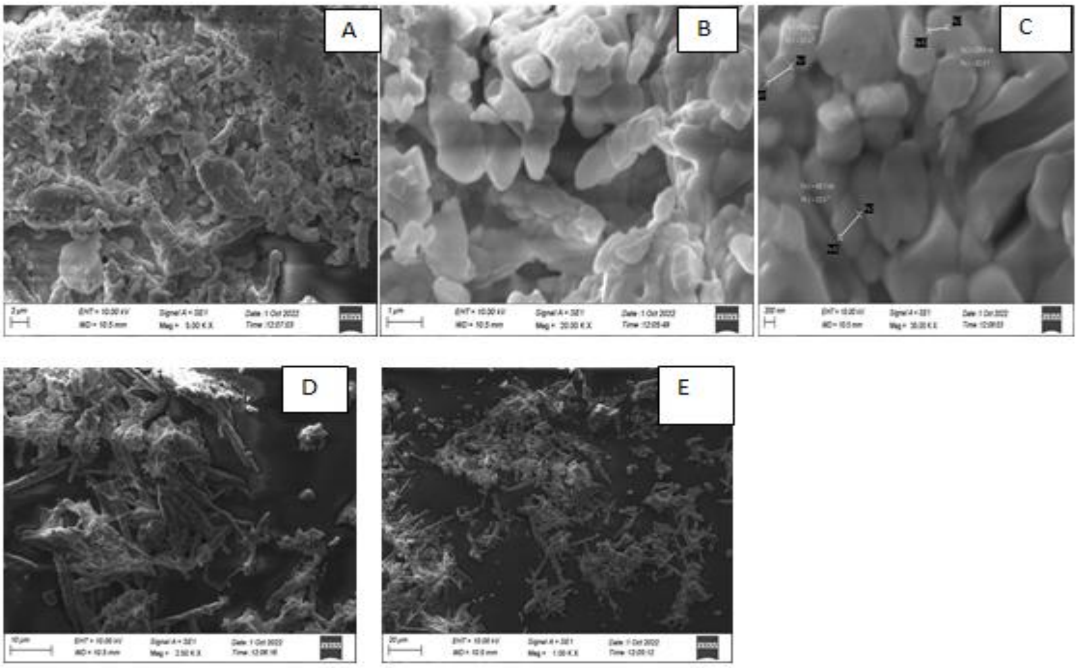

Figure 8(A), (B), (C), (D), (E). SEM Images of $GAPbBr_3$ thin film.

X-Ray Diffraction

C

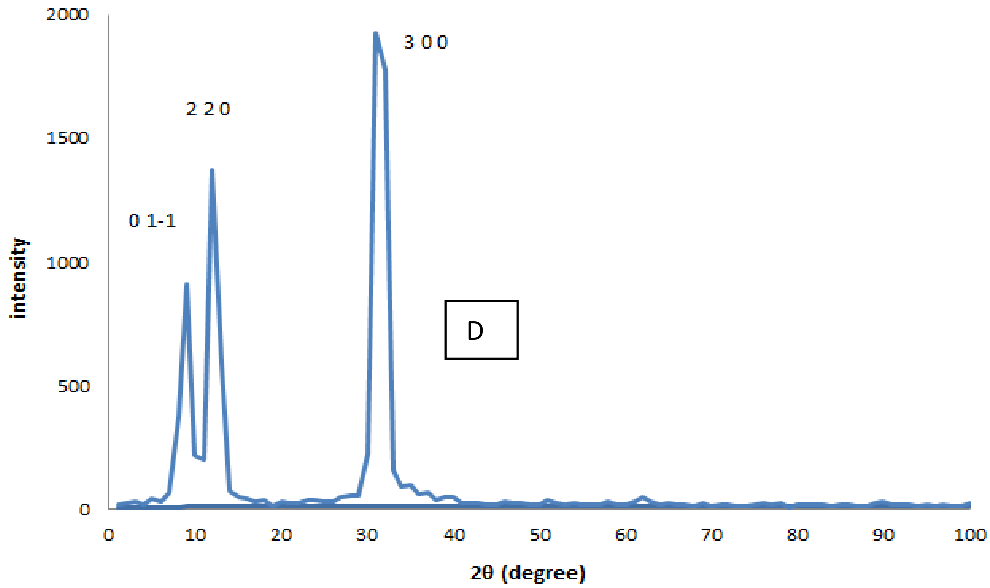

Figure 9 XRD Diffraction Spectrum of $GAPbBr_3$ thin film.

The above figure 9 shows the XRD diffraction analysis of the $GAPbBr_3$ thin films annealed at 300˚C for perovskite is found to be polycrystalline in nature. The structural properties of the coated thin film are studied by using CuKα whose Bragg's angle ranging from 11 to 70 of 2θ. The obtained X-Ray diffraction pattern is compared with (JCPDS 96-431-9068). The corresponding peaks (01-1), (220), (300) are obtained. The average grain size value is found to be 52.5811 nm.

Fluorescence Spectroscopy

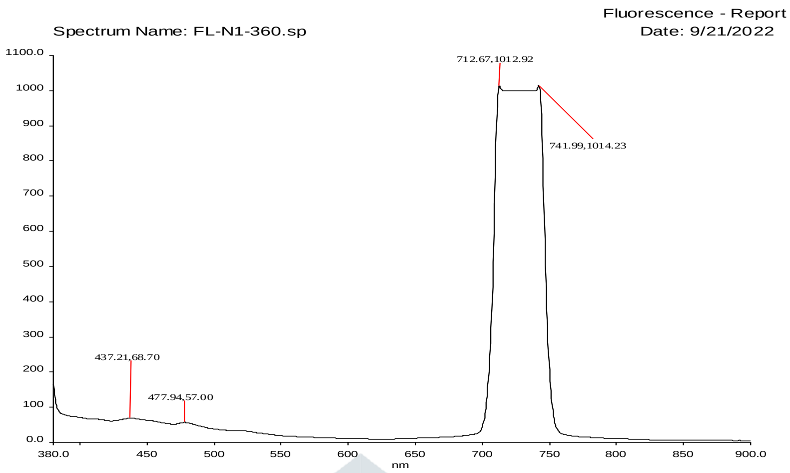

Figure10 .Fluorescence Spectrum of $GAPbBr_3$ thin film.

The above figure 10 shows the fluorescence spectrum of the $GAPbBr_3$ thin films for perovskite absorbent layer. After excitation by photons the electrons-holes recombine a various pressure. The graph shows four emission peaks. The peak at 437.21 nm, can be ascribed as self-dropped excitons localized on perovskite layer and peak at 741.99 nm is associated with oxygen vacancies.

THICKNESS MEASUREMENT

The thickness of the $GAPbBr_3$ thin film for the perovskite absorbent layer is calculated using surface profoliometer which measures by using contacting and scanning. The average thickness of the Guanidinium lead bromide thin film is found to be 3. 2632µm.

CONCLUSION

The $GAPbBr_3$ thin films for perovskite absorber layer for solar cells and LED's are coated using drop casting method and the characteristics were studied. The optical properties are mainly studied using the UV spectroscopy, Photoluminescence Spectroscopy, Fluorescence Spectroscopy and FTIR which confirms the presence of ammonia, Halogens. The structural characteristics has been analysed by X – Ray diffraction and the average grain size is 52.5811 nm . The perovskite layer is generally capable of absorbing sunlight and thus the SEM images confirm porous structure. Finally the thickness is measured by using surface profilometer is 3.2632µm. Thus Guanidinium Lead Bromide thin film absorber layer will be suitable material for perovskite solar cell and LED fabrication.

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