Synthesis and Characterization of Cspbibr₂ Thin Films Using Organic/ Inorganic Materials

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ABSTRACT

The development and examination of perovskite solar cells (PSCs) with organic–inorganic hybrid perovskite materials was undertaken in this study. Thin films of $CsPbIBr_2$ were prepared through spin-coating, which was followed by thermal annealing for different durations and temperatures in order to study the thin films' structures and optical properties. The films were examined through X-ray diffraction (XRD), scanning electron (SEM) and transmission electron microscopies (TEM), along with UV–Vis spectroscopy. The results showed enhanced crystallinity, optical transparency, and annealing. The results of this study support the use of $CsPbIBr_2$ in PSCs to convert solar energy to electricity, as well as emphasize the importance of variable controlled synthesis to improve device stability and efficiency.

INTRODUCTION

The increasing demand for renewable energy has certainly triggered growth in research around advanced photovoltaic technologies. Perovskite solar cells (PSCs) stand out as the most favorable options owing to their cheap and easy-to-fabricate construction along with light-weight structure and amazing efficiency gains in slightly over a decade [1–3]. First reported with 3% efficiency in 2009, PSCs have achieved power conversion efficiencies in excess of 25%, posing competition to the traditional silicon photovoltaics [4,5]. This is possible because of their hybrid organic–inorganic halide structure, most often ABX_3, because of the high absorption coefficients, tunable band gaps, and long carrier diffusion lengths [6,7]. In addition, PSCs are easily made using low temperature solution processes, making them ideal for flexible and scalable applications [8,9]. Still, there is the problem of moisture sensitivity, thermal instability, and lead toxicity, which barriers to commercialization [10–12]. This research covers the fabrication of thin films of $CsPbIBr_2$ as well as the structeral and optical characterizations, and the impact of device performance using different annealing temperatures.

METHODOLOGY

The fabrication of CsPbIBr2 thin films was conducted using a one-step spin-coating method. Cleaning the substrate was vital to guarantee deposition without defects. Glass substrates were first washed with a detergent, then rinsed with distilled water, treated with isopropanol (IPA) and acetone, and dried at 60 °C. Each PbBr2 precursor, which was possessed as 800 mg dissolved in 2 ml of DMSO at 70° of a stirred solution, was prepared by adding which was equipped with 600 mg CsI. The solution was then stirred at 70° for 30 minutes. Disposing of the thin films took place when the solution was placed in the spin coater, which was engineered for a maximum speed of 6000 RPM for glass substrates over the course of 15 seconds. The thin films were then annealed to analyze the effects of temperature and crystallinity, with a range of 25° celsius to 250° celsius. The methods absorbed involved analyzing the films through X-ray diffraction (XRD), scanning electron microscopy (SEM) and Transmission Electron Microscope (TEM), with Atomic Force Microscope (AFM) for the deposition surface. The optical mechanisms were recorded through the UV-Visible Photodetector.
The results obtained from J-V measurement and external quantum efficiency (EQE) were directly related to the appearance and activity of the films which were a result obtained from external methods. This set of processes proved the importance of annealing.

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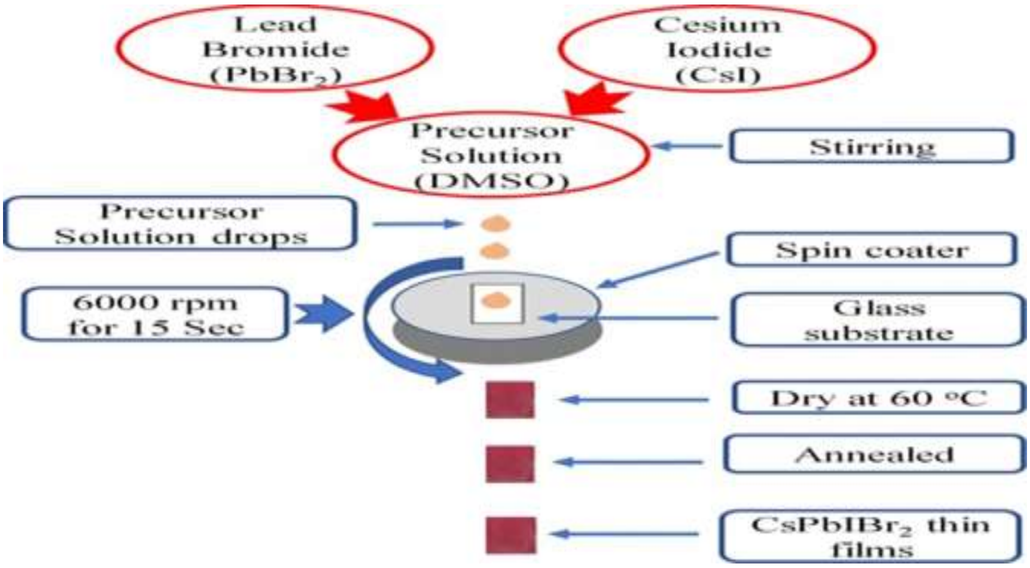


FIGURE : Experimental work flowchart for the preparation of precursor solution and deposition of CsPbIBr2 thin film.

RESULT AND DISCUSSION:

XRD analysis indicated the size of the crystallite peaked at size of ~62 nm at approximately 200°C and considerably increased the annealing temperature. SEM and TEM indicated the presence of uniform crystal growth and optical results showed better transparency and smaller extinction values, indicating an increased optical effect at higher annealing temperatures. Definitive absorption in the visible region shown in the UV-Vis spectra demonstrates this material can be used in photovoltaic devices and annealing these materials in a controlled manner balances the crystallinity and optical response of the thin films improving their use in solar cells. It can be concluded from this study, the cesium lead halide perovskite material is highly promising for use in next generation perovskite solar cells, but work remains on stability, civilization, and ecological concerns.

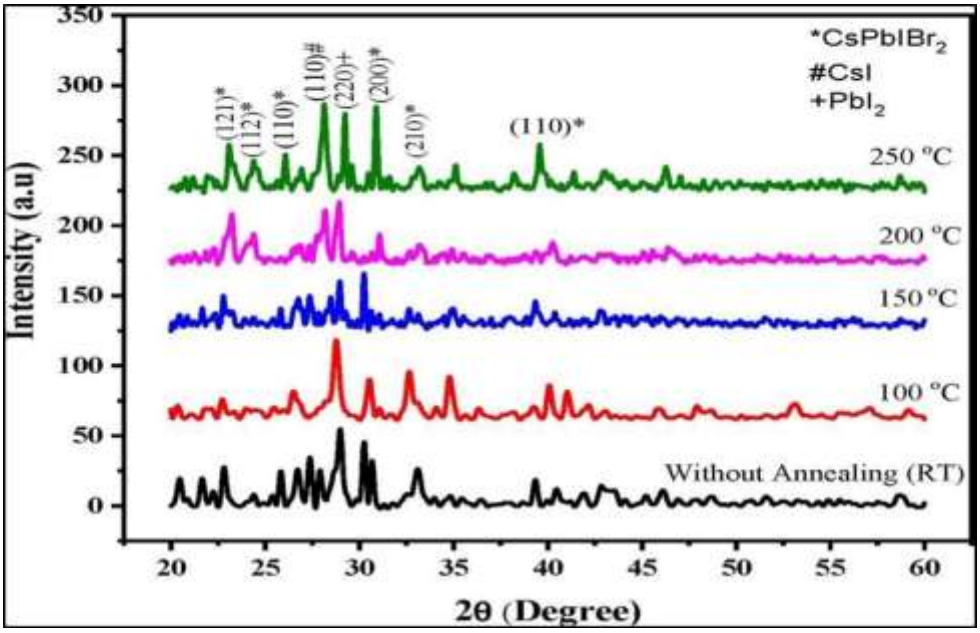


FIGURE: X-ray Diffraction Study of $CsPbIBr_2$ Thin Films Synthesized through various temperatures used for annealing.

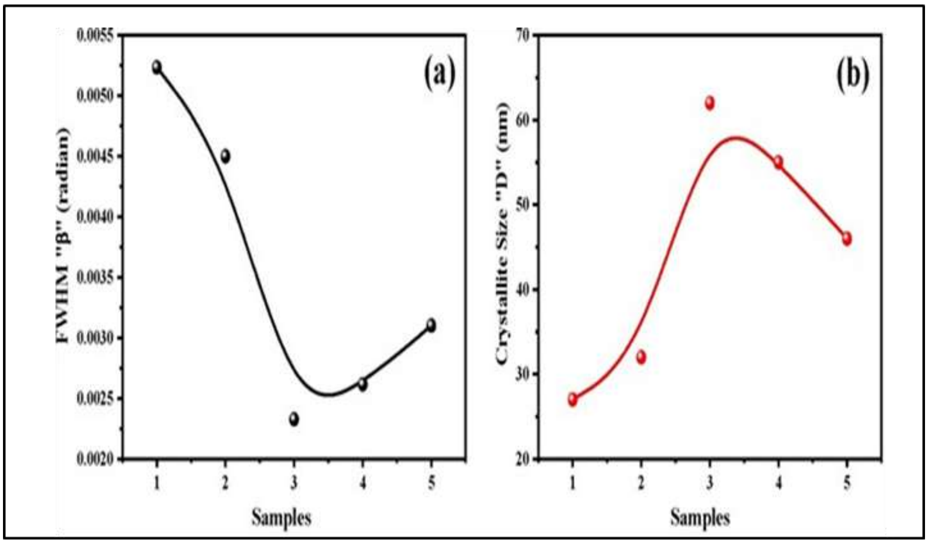


FIGURE: shows how structural parameters affect the annealing temperature of $CsPbIBr_2$ thin films: (a) β; (b) D

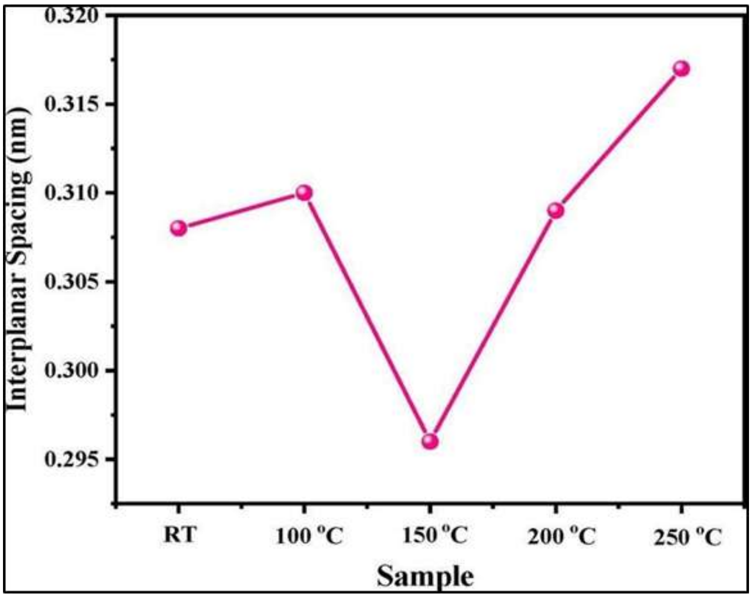


FIGURE: This figure illustrates the relationship between interplanar gaps at $CsPbIBr_2$ thin films as well as the different annealing temperatures at which they were manufactured

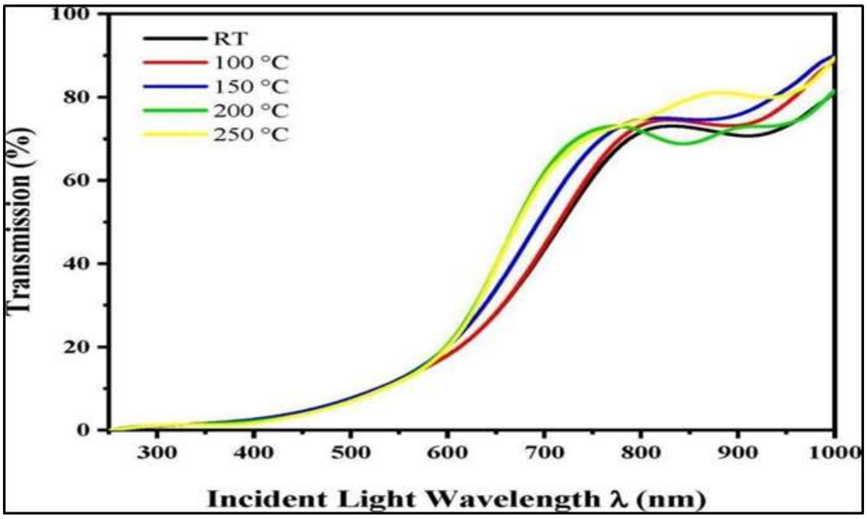


FIGURE: This figure illustrates the transmission spectra of $CsPbIBr_2$ thin films subjected to cooling at different conditions.

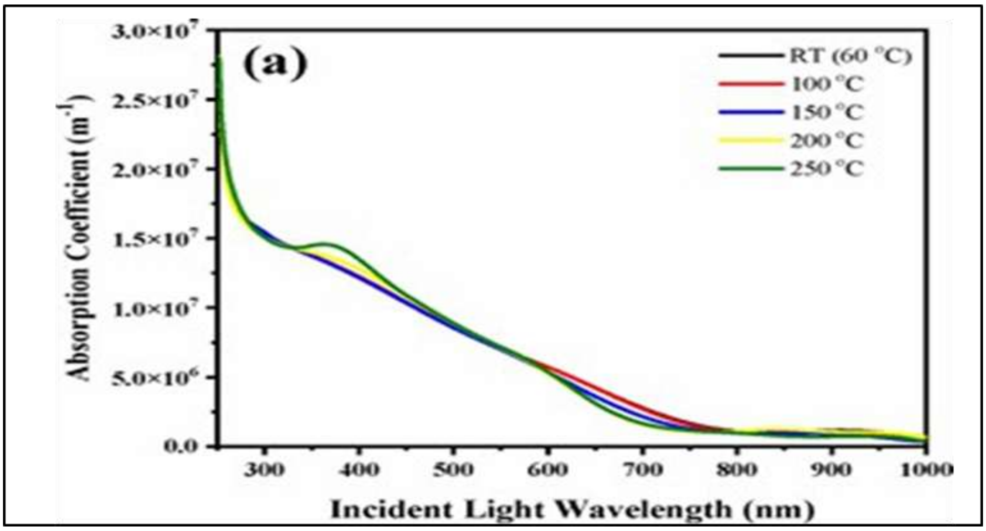
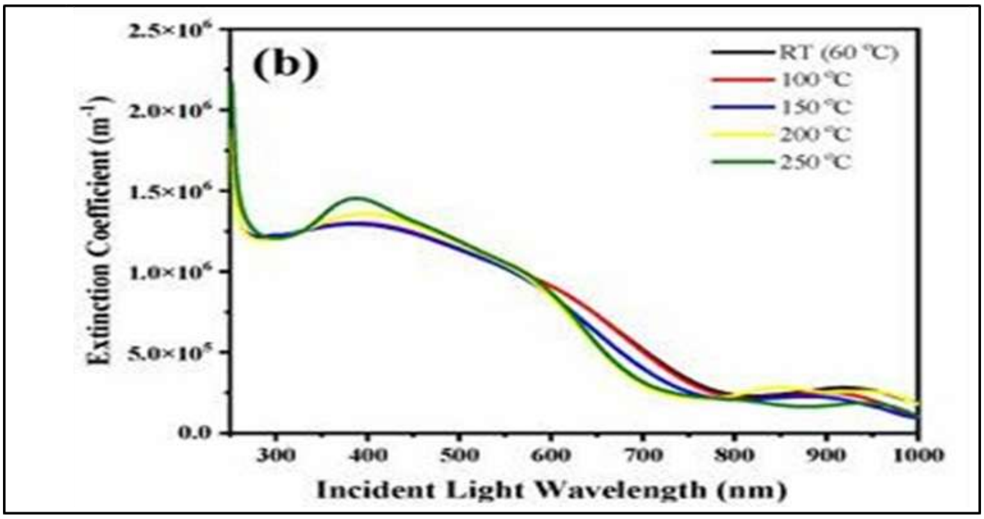


FIGURE: shows the relationship between the absorption and extinction indices of $CsPbIBr_2$ over various annealing temperatures.

(a) graph: Wavelength versus. Absorption Coefficient



(b) Extinction Parameter vs. Wavelength:

CONCLUSION:

This study highlights the advances and problems in PSC technology. Material durability and efficiency have improved significantly as a result of regulated synthesis and structural optimisation. However, concerns about environmental effect, particularly lead toxicity, remain significant barriers to wider implementation. The study also emphasises the possibility of lead-free substitutes, that display promise but require additional development to achieve the efficiency of their lead-based counterparts. Future perspectives emphasise the importance of scalable production methods and the creation of ecologically stable materials in order to provide large-scale, environmentally acceptable energy solutions. Addressing these problems will be critical to the financial sustainability of PSCs, which have the potential to greatly assist in the global transition towards renewable energy.

References

1. Liu, G. (2017). Fabrication and characterization of planar-structure perovskite solar cells.
2. Jafar, A. M. (2020). Fabrication and characterization of perovskite solar cells.
3. Mishra, A. K., et al. (2020). Fabrication of perovskite solar cells under controlled humidity conditions. SN Applied Sciences, 2(2), 2054.
4. Tayari, F. (2025). Recent advancements in fabrication and characterization techniques of perovskite nanomaterials. *Nanomaterials, 15*(3).
5. Suzuki, A. (2025). Metal phthalocyanines and naphthalocyanines as hole-transport materials for $MAPbI_3$ PSCs. *Proceedings, 87*(1).
6. Park, N.-G. (2020). Research direction toward scalable, stable, and high-efficiency PSCs. *Chemical Reviews, 120*(15), 8015–8035.
7. Hossain, K. (2024). Compositional and interface engineering in hybrid perovskite thin films. *arXiv:2411.17919*.
8. Siegrist, S., et al. (2021). Large-area triple-cation PSCs by hybrid PVD/blade coating. *arXiv:2108.13794*.
9. Green, M. A., et al. (2020). Solar cell efficiency tables (version 55). *Prog. Photovoltaics, 28*(1), 3–15.
10. Cheng, Y., & Ding, L. (2021). Pushing commercialization of PSCs by improving stability. *Energy & Environmental Science, 14*(6), 3233–3255.
11. Mazumdar, S., Zhao, Y., & Zhang, X. (2021). Stability of PSCs: Degradation mechanisms and remedies. *Frontiers in Electronics, 2*, 712785.
12. Grätzel, M. (2014). The light and shade of perovskite solar cells. *Nature Materials, 13*(9), 838–842.