Materials and Device Characteristics of Methyl Ammonium Lead Iodide and Caesium Tin Iodide Absorbers for Perovskite Solar Cells

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INTRODUCTION

Despite the high efficiencies attained by perovskite based solar cells, the presence of lead in the best performing cells to date has proven to be the greatest drawback to the implementation of this technology. Attempts to replace lead with tin thus far has led to instability issues associated with hydrolysis and phase transitions.

THEORY

The recent report of Cs_2SnI_6's successful incorporation as a hole transporter in a solid-state dye sensitized solar cell has piqued interest towards its viability as an absorber layer. Some of the key advantages associated with the use of Cs_2SnI_6 as an absorber includes its air and moisture stability enabling ambient processing, ambipolar charge transport properties and high optical absorption.

METHODS

This paper aims to; synthesise and characterise $CH_3NH_3PbI_3$ and Cs_2SnI_6 thin films, investigate and compare their opto-electronic properties as well as fabricate and analyse their device characteristics in a bid to assess Cs_2SnI_6 suitability as a substitute for $CH_3NH_3PbI_3$.

RESULTS

TGA measurements revealed thermal stabilities of up to 200°C for both materials, resulting in a trade-off between higher crystallinity and material decomposition. Despite the high absorption exhibited, significantly lower efficiencies were recorded for Cs_2SnI_6 based devices. This was attributed to the band misalignment at the TiO_2/Cs_2SnI_6 interface coupled with poor surface coverage and loading into the TiO_2 scaffold, leading to inefficient charge transfer and large contribution by parasitic resistances. Presence of traps further suffered J_{SC} and V_{OC} and in turn deteriorated the device performance. On the other hand, steep efficiencies shown in $CH_3NH_3PbI_3$, stemmed from the high J_{SC} and V_{OC} values linked to low exciton binding energies, small effective carrier masses, low defect density and high absorbance afforded by the perovskite crystal.

CONCLUSION

Optimising film properties and identification of more suitable electron/hole transporting layers will aid in improving device performance. Gaining deeper understanding of the trap formation mechanism and kinetics would enable the synthesis of trap-free Cs_2SnI_6. Issue of band misalignment and ineffective charge transfer can be rectified by substituting TiO_2 photo-anode with ZnO or PCBM. Through optimisation of material characteristics, this will pave the way to a new generation of lead-free, stable yet efficient solar cells.