IET International Travel Award Report 2023

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In October 2023, I was fortunate to be selected for one of the IET International Travel Awards to attend and present my PhD work on mixed-metal halide perovskites in the **Materials Research Society (MRS) Fall Meeting**, held during 26 November-1 December at the Hynes Convention Centre in Boston, United States. This is undoubtedly the most prestigious scientific conference in the field of materials science across the world and I was honoured to attend this for the first time. Moreover, 2023 marked the 50th year of advancing materials research by MRS and hence the scale of the conference was bigger than ever before.

In this conference, I delivered three oral presentations, which was quite special as it is usually very hard to have even one accepted oral presentation in such conferences due to the submission of a massive number of abstracts from everywhere around the world. In my first talk, entitled "*Substitution of Lead with Tin Suppresses Ionic Transport in Halide Perovskite Optoelectronics*", I discussed our combined experimental-theoretical approach of understanding the impact of tin substitution on the ion migration in lead halide perovskite solar cells. By conducting scan-rate dependent current-voltage measurements, we observe short-circuit current loss at lower scan rates (< 50 mV/s) for both Pb and Pb-Sn perovskite devices, thereby indicating the prevalence of ionic migration in both kinds of solar cells. However, the kinetics of ionic transport is found to be suppressed in mixed Pb-Sn systems as inferred from scan-rate dependent hysteresis measurements. These results are further corroborated by temperature-dependent impedance spectroscopy measurements performed on the fabricated devices at open circuit and under light illumination, which suggest a substantial lowering of ionic diffusion with the partial substitution of Pb with Sn. In addition, atomistic ab initio simulations highlight the key role played by Sn vacancies in increasing the iodide ion migration barriers (>1.1 eV) in Sn-containing perovskites due to severe local structural distortion, which corroborates and rationalises our experimental observations of much slower ion diffusion in mixed Pb-Sn perovskite solar cells. This work is also recently published in the journal "*Energy and Environmental Science*" (impact factor: 39.714), which can be found here.

In my second talk, entitled "*Probing Photostability of Tin-Containing Mixed Halide Perovskites: The Good and the Bad*", I presented our systematic study of the impact of Sn incorporation on the remarkable improvement in the photostability of mixed halide perovskites, which are otherwise plagued by the challenge of halide segregation thereby impacting the solar cell performance and stability. We also investigate the impact of light soaking on the resulting charge carrier dynamics and charge transport in mixed halide perovskites with and without Sn in the composition, which again exhibit distinctive trends. Next, we rationalize the contrasting trends of photostability of Pb-only and mixed Pb-Sn mixed halide perovskites by suggesting a hypothesis of preferential Sn^{2+} oxidation over I^- oxidation in the presence of photogenerated holes, which seems to explain most of our experimental observations. Finally, we highlight important differences in the degradation pathways of Pb-only and mixed Pb-Sn based solar cells, thereby indicating that the seeming absence of halide segregation in mixed Pb-Sn devices does not alone guarantee an improvement in their operational stability. This work is currently under preparation for submission to a high quality scientific journal imminently.

In my third and final talk, entitled "*Understanding Charge Transport in High Performance Mixed Lead-Tin Halide Perovskite Transistors*", I showed that field-effect transistors based on methylammonium-free, mixed metal (Pb/Sn) perovskite compositions do not suffer from ion migration effects as notably as their pure-Pb counterparts and reliably exhibit hysteresis-free p-type transport with a mobility reaching 5.4 $cm^2V^{-1}s^{-1}$. The reduced ion migration is visualized through photoluminescence microscopy under bias and is manifested as an activated temperature dependence of the field-effect mobility with a low activation energy (~48 meV)

consistent with the presence of the shallow defects present in these materials. This work represents a significant step ahead in the understanding of long-range charge transport in halide perovskites and it was published in the journal "*Nature Materials*" (impact factor: 47.656), which can be found here.

MRS Fall 2023 had 64 symposiums on a range of material families and thus this was an excellent opportunity for scientists and engineers around the world to discuss the latest developments in the field and build connections. As a new postdoctoral researcher, I very much enjoyed networking with my peers during the poster sessions and tea and lunch breaks over those 3 days. My talks also attracted a large audience, and such interaction really helped me to get useful feedback on my work. It also helped me to project and highlight my work to the broader community, which is important to remain visible in this crowded research space.

One of the most significant takeaways for me was that I was able to visit the research labs of the 2023 Nobel Laureate (Chemistry) Professor Moungi Bawendi at MIT. Boston being a university city, it was great to visit the campuses of MIT, Harvard University and Tufts University, which are all located close to each other. Long discussions with acquaintances in those universities also gave me a broad overview of the US academic system, which was really helpful given my intention of moving to US next year. Overall, this trip was really fruitful and enjoyable and therefore I wholeheartedly thank the IET for awarding me with a prestigious travel grant. I very much appreciate the support from IET over the last two years and I hope to continue working with them for times to come.

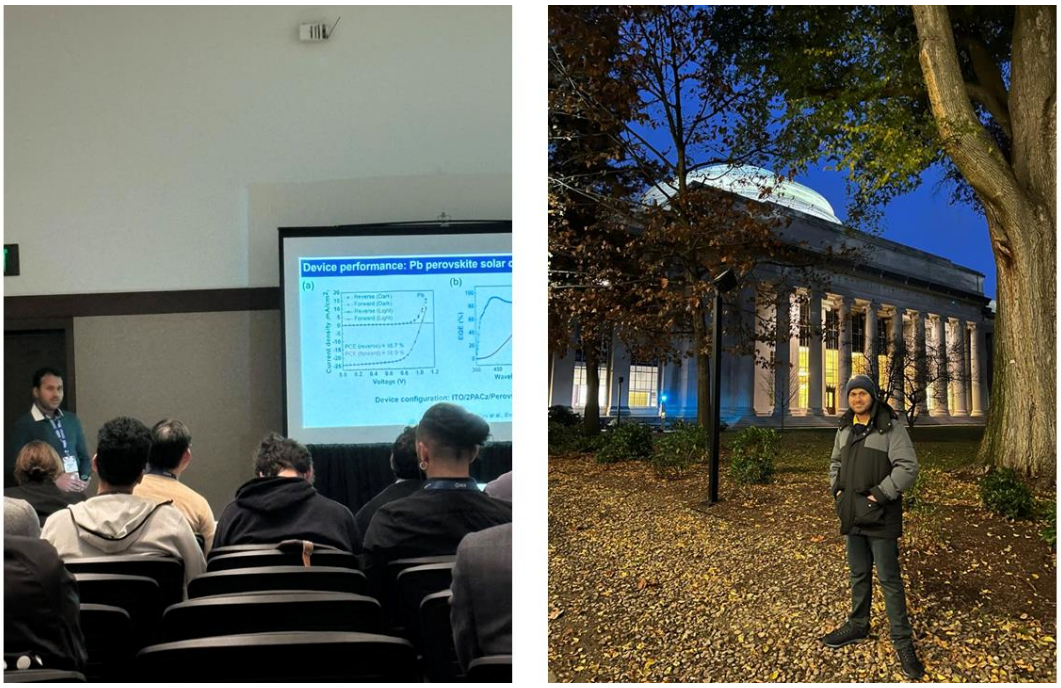

Photo: (LEFT) Krishanu Dey delivering his first talk to the attendees at MRS Fall 2023 Meeting

(RIGHT) Krishanu Dey visiting the MIT campus across the Charles River in Boston