Progress in inorganic perovskite ($CsPbX_3$) photovoltaic cells

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$CsPbX_3$-based photovoltaic (PV) cells have made rapid gains in the past year, with top conversion efficiencies close to 17%. All-inorganic halide perovskites (HaPs) possess much greater thermal stability than the hybrid organic-inorganic ones and often other measures of stability as well. $CsPbI_3$, has a bandgap of ~1.7 eV which is ideal for the short-term holy grail of the HaP PV community - a two-junction tandem cell with silicon. $CsPbI_2Br$ has also been extensively studied over the past year; it has a bandgap of ~1.9 eV which would be ideal for a triple tandem with silicon. However, these inorganic HaPs also have their problems, in particular the poor phase-stability of black (usually α-phase) $CsPbI_3$. The higher phase stability of photoactive $CsPbI_2Br$ is the main reason for the recent great interest in this material. In addition, the voltage loss (compared to the theoretically-expected loss) is greater than for the hybrid HaPs (of similar bandgap – this voltage loss is greater for higher bandgaps in general). Up to now, there is no clear explanation for the lower voltage efficiency of either Cs vs. organic (or mixed organic/inorganic) cation or for higher vs. lower bandgaps.

In this talk, we describe the present knowledge on $CsPbX_3$, first considering relevant materials properties and then PV cells based on these HaPs. Emphasis on the first part will be on phase stability of the HaPs (mainly $CsPbI_3$) and strategies taken to improve this stability, including variations in the formation/deposition of the HaP such as reduction of crystal size use of other crystal phases, lowering of HaP dimensionality (mixed 2D/3D) and incorporation of foreign elements.

Following this, PV cells based on these materials are described according to variations in halide compositions (iodide, bromide and mixed iodide/bromide). Various strategies adopted to increase efficiency and/or stability are discussed. Because of the greater voltage loss in the Cs HaPs, which is an important cause of lower conversion efficiencies compared to hybrid HaP cells, we particularly consider the open circuit voltage in this discussion.

Finally, we present several directions that we feel to be important to further improve these inorganic HaPs and their cells.