Compositional Tailoring of Inorganic $CsPbX_3$ (X = Cl, Br and I) Perovskite Quantum Dots for Solar Cells

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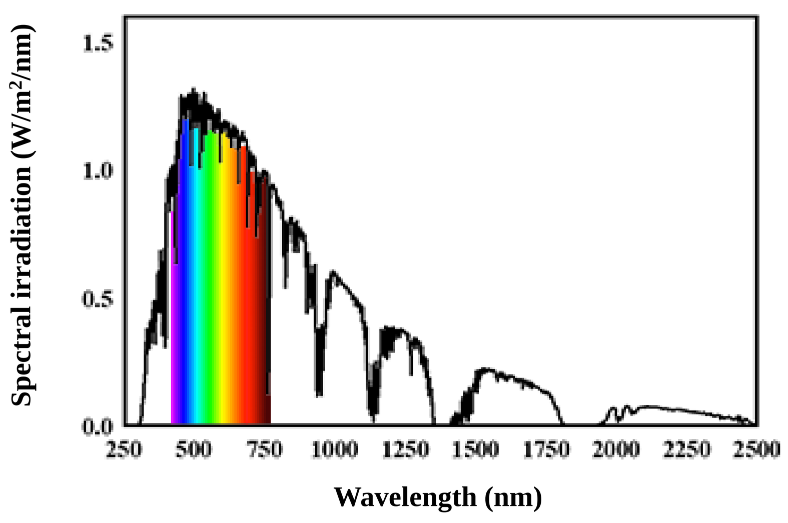
Introduction

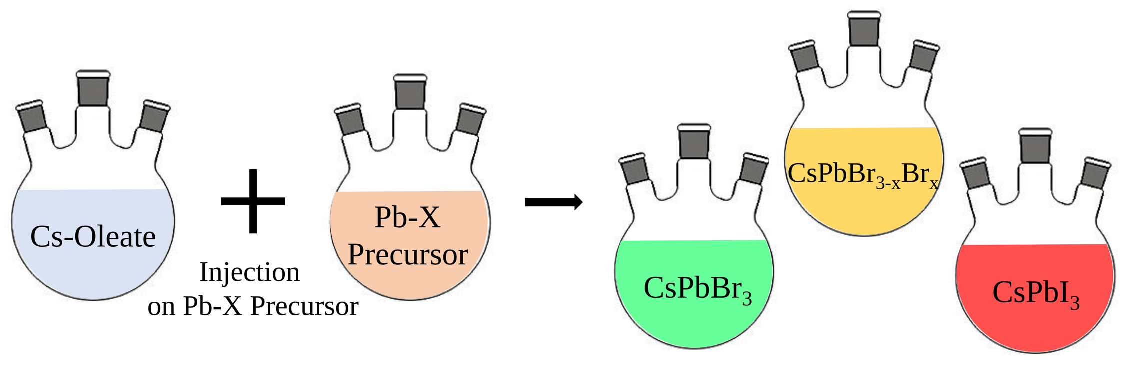
Quantum Dots (QDs), a few nanometers of semiconductor, have novel properties that their optical properties can be tuned depending on the sizes. In specific, perovskite QDs have attracted attention due to their unique properties such as high photoluminescence (PL) quantum yields and tunable bandgap.



With Increasing demand on clean energy, solar cells, especially perovskite quantum dot solar cells, have attracted a lot of attention since it can be produced through low-temperature and all-solution process. When choosing materials to utilize as active layer of solar cell, it is necessary to confirm whether it can absorb the light that comes with wavelength that has high intensity in solar energy spectrum. In this study, we demonstrated the proper ratio of Halides in CsPbX3 (X= Cl, Br and I) quantum dots in regarding both the spectrum and the bandgap.

Experimental Methods

Synthesis of CsPbX3 (X = Cl, Br, I) Quantum Dots

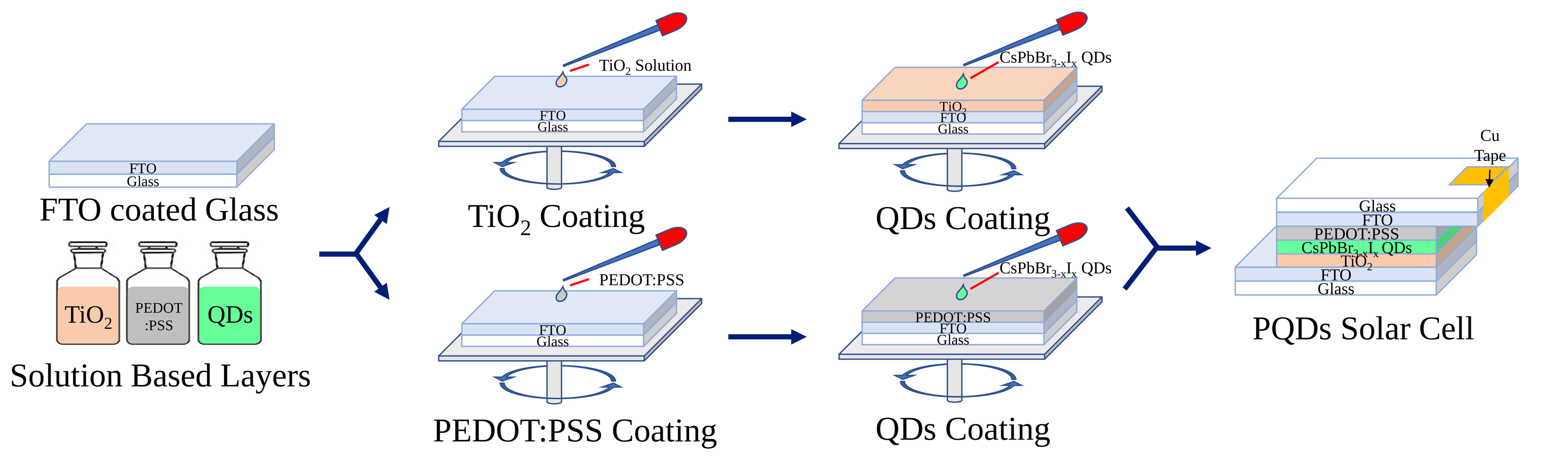


Cs-Oleate:
$Cs_2CO_3 + 2OA \rightarrow 2CsOAc + H_2O + CO_2$

Pb-X Precursor:
$PbX_2 + 2OAc + 2OAm \rightarrow 2PbOAc_2 + OAmX$

$CsPbX_3$ Synthesis:
$CsOAc + PbOAc_2 + 3OAmX \rightarrow CsPbX_3 + 3OA^- + 3OAm^+$

Fabrication of Solar cell based of All-solution Process



Results

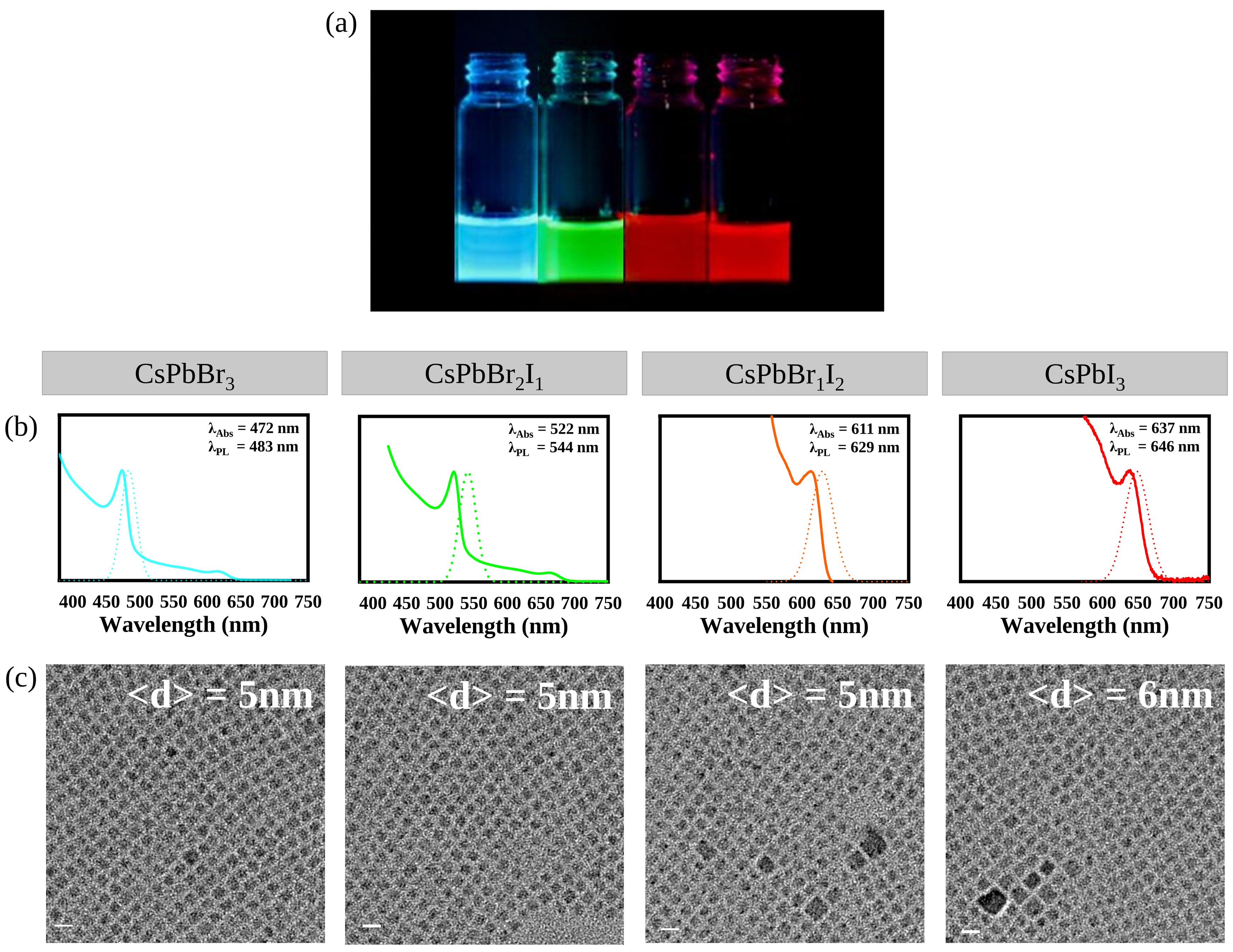


Figure 1. (a) Colloidal perovskite $CsPbBr_xI_{3-x}$ QDs dispersions (in each vial, the QDs have a different halide composition) in hexane under an UV lamp (λ = 312 nm) The image shows $CsPbBr_3$, $CsPbBr_2I_1$, $CsPbBr_1I_2$ and $CsPbI_3$ respectively. (b) Absorption (solid line) and PL spectra (dot line), (c) Transmission electron microscopy (TEM) images of $CsPbBr_xI_{3-x}$ QDs.

Table 1. Optical properties of $CsPbBr_xI_{3-x}$ QDs

	Avg. size(nm)	λ_{Abs}(nm)	λ_{PL}(nm)
$CsPbBr_3$	5	472	483
$CsPbBr_2I_1$	5	522	544
$CsPbBr_1I_2$	5	611	629
$CsPbI_3$	6	637	646

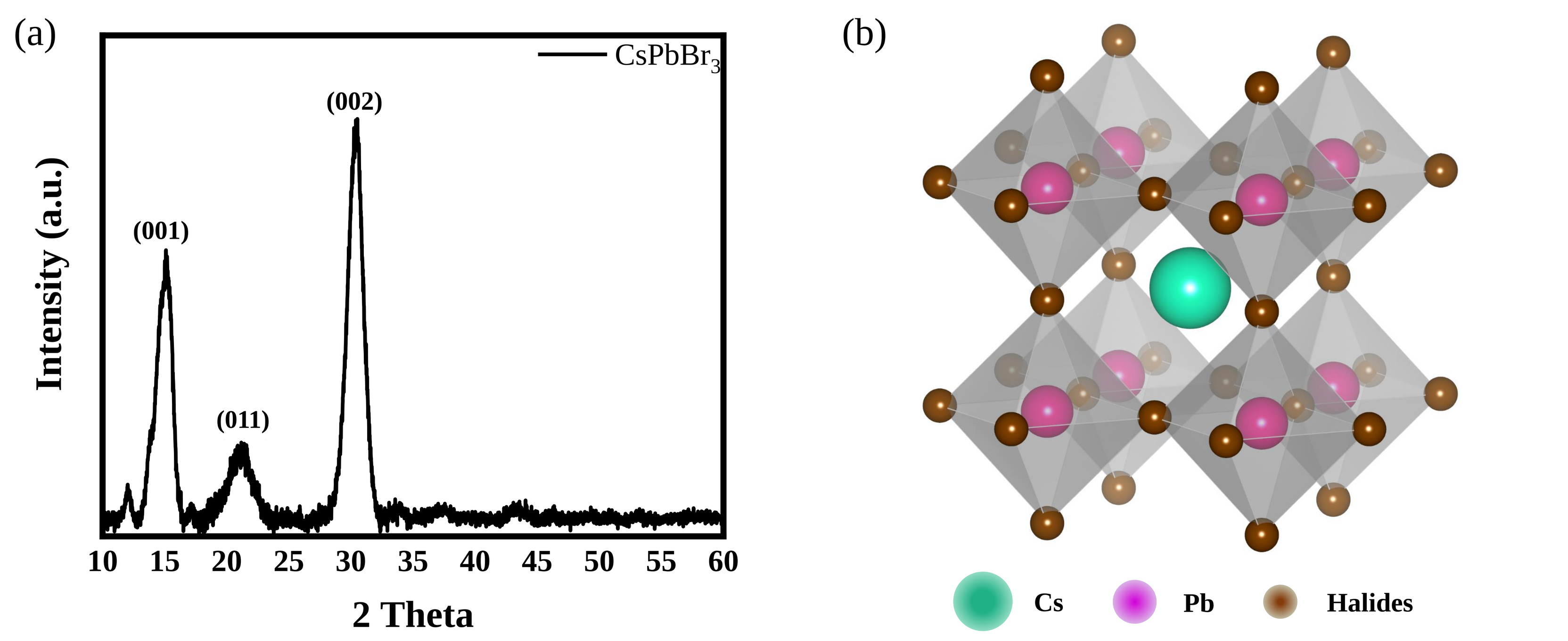


Figure 2. (a) X-ray diffraction (XRD) pattern of $CsPbBr_3$, (b) Structure of $CsPbX_3$ (X = Cl, Br and I) Perovskite

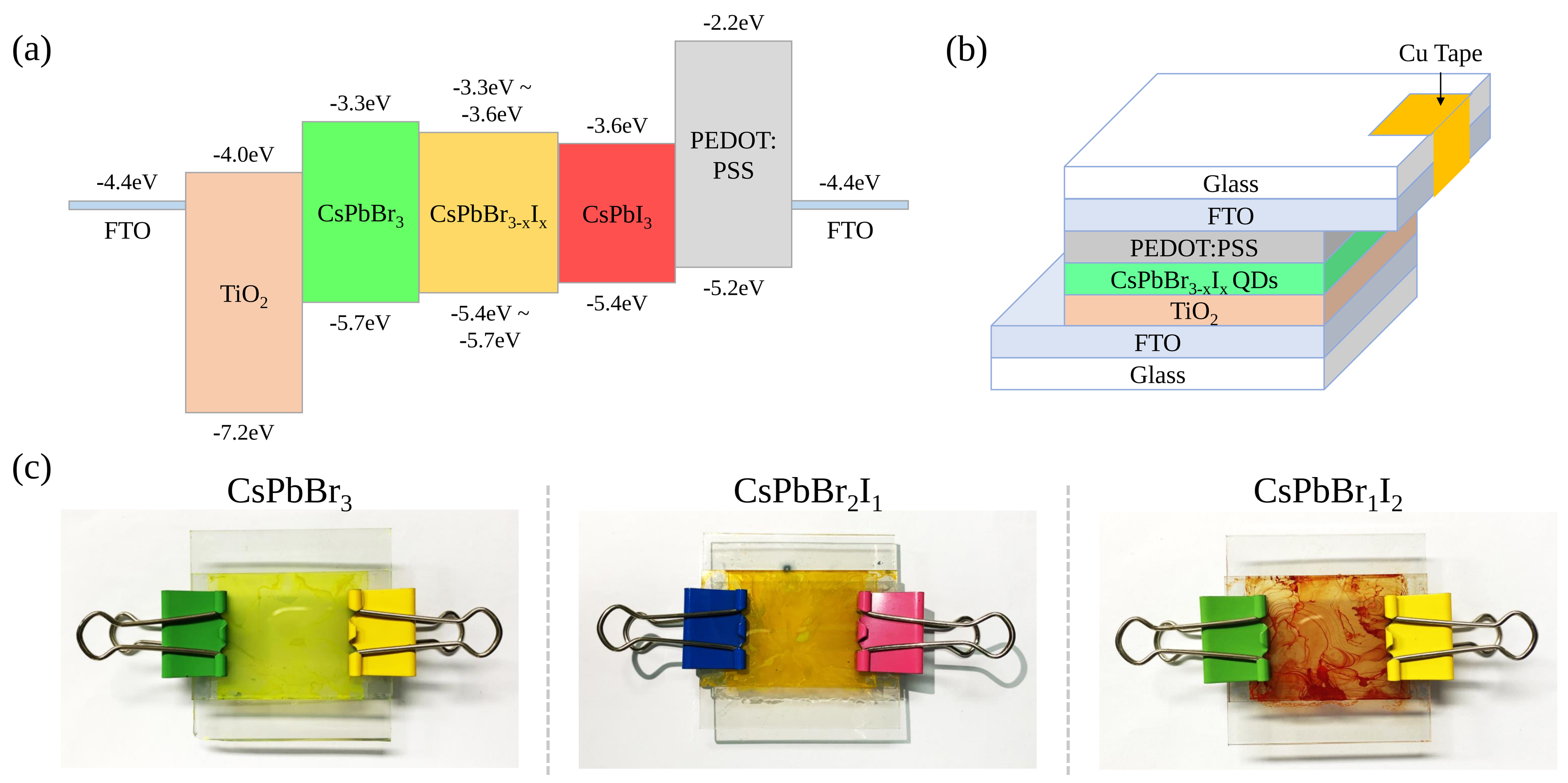


Figure 3. (a) Bandgap energy diagram of solar cell, (b) Structure of solar cell, (c) Photographs of three solar cell devices

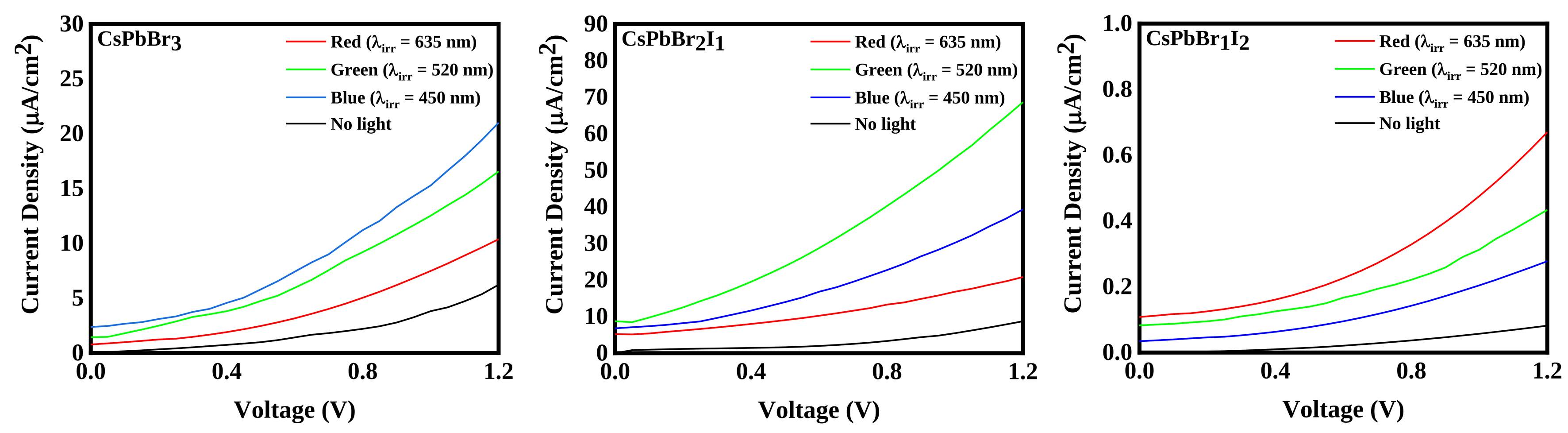


Figure 4. Current density-Voltage curve under Red(635nm), Green(520nm), Blue(450nm) radiations

Conclusion & Further Study

Our team has investigated the ratio of halide compositions in $CsPbBr_xI_{3-x}$ QDs , with respect to the bandgap and solar energy spectrum to utilize for solar cells. Using UV-Visible Spectroscopy, four QDs with different halide ratios; $CsPbBr_3$, $CsPbBr_2I_1$, $CsPbBr_1I_2$, $CsPbI_3$ were found to be in the wavelength intervals that can be used for active layer of solar cells.

We were able to verify the feasibility for applying $CsPbBr_xI_{3-x}$ QDs to solar cells by fabricating three preliminary photovoltaic devices using $CsPbBr_3$, $CsPbBr_2I_1$ and $CsPbBr_1I_2$. With further studies, it is expected to be applicable in many fields that require solar energy utilization.

Reference

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