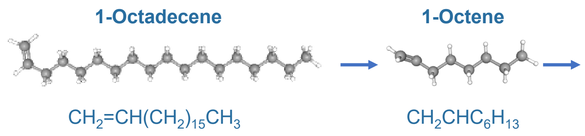
Surface engineering of $FAPbI_3$ hybrid perovskite quantum dots for photovoltaic applications

研究の目的 – Motivation

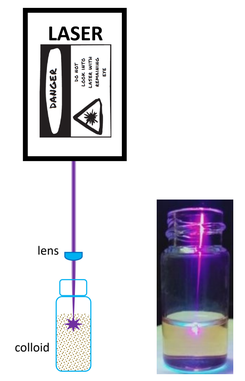
- Improve electronic coupling between $FAPbI_3$ quantum dots (QDs) through efficient ligand exchange[1]
- Enhance photocarrier transport within spin-coated layers of QDs
- Push the efficiency of $FAPbI_3$ photovoltaic cells based on QDs-only and bulk/QD junctions[2]
- Study effect of $FAPbI_3$ QDs on the stability of bulk $FAPbI_3$ films[2]

実験 – Experiment

I. Use of 1-Octene instead of 1-Octadecene during the hot injection synthesis



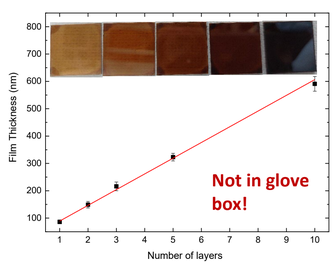
- hot injection
- purification
- spin coating with ligand exchange



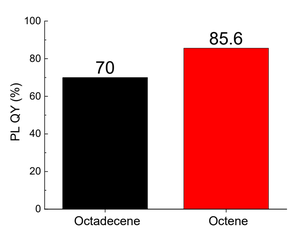
II. Exposure of QD colloids to a fs-laser treatment[3]

結果 – Results I

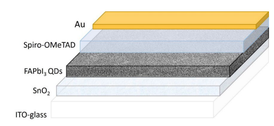
- Smooth films spin-coated in atmosphere

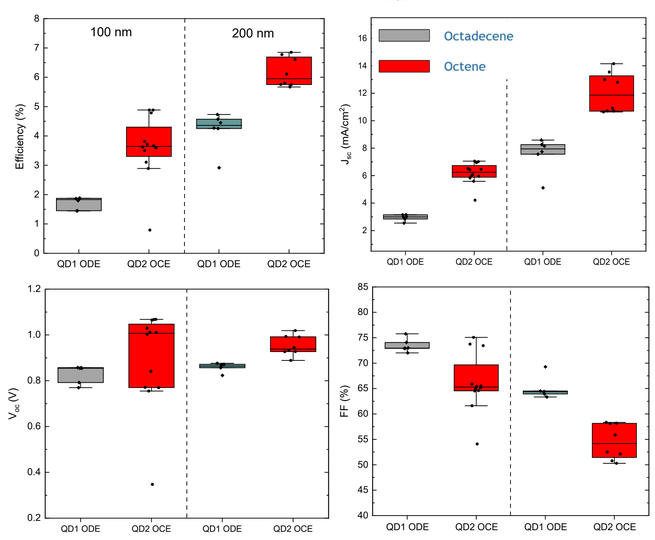


- Higher photoluminescence quantum yield



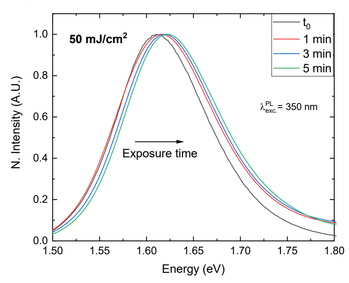
- QD-only PV cells show better performance except for FF



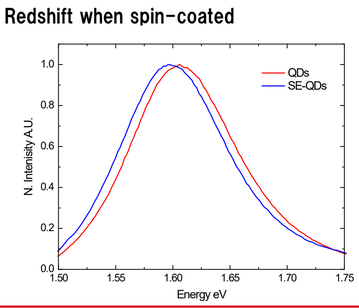


Results II

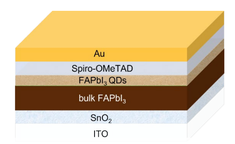
- Progressive PL blueshift for longer laser exposure

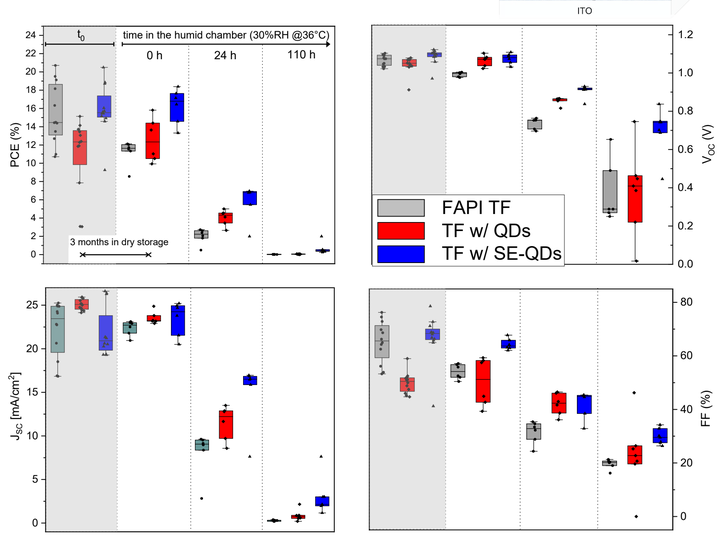


- Redshift when spin-coated



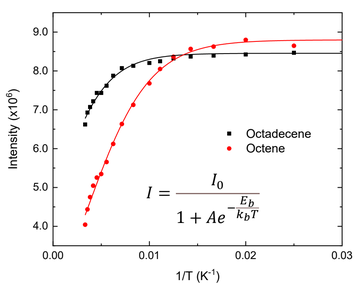
- PV cells using thin adlayers of QDs show better V_{OC} for treated QDs SE-QDs) and significant resistance to humidity



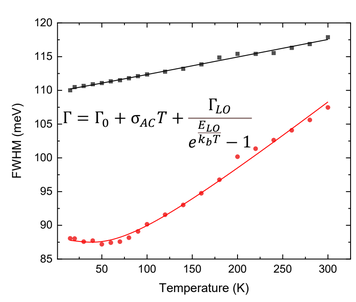


考察 – Analysis I

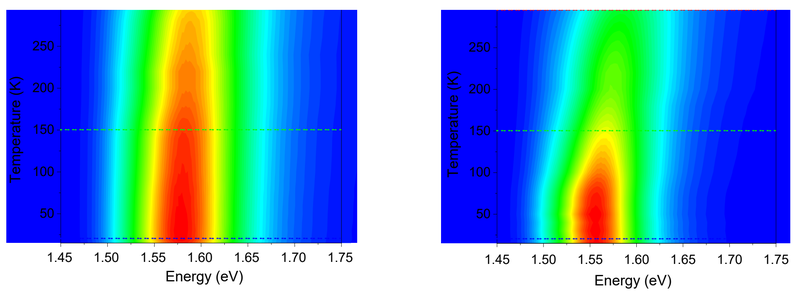
- Intensity T decay linked to exciton binding energy[4]



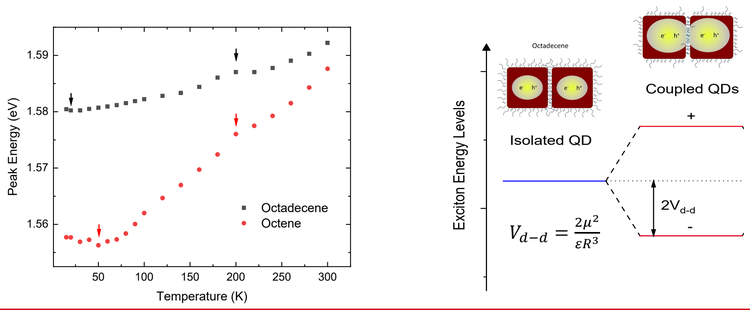
- Shaper emission and variation at low T depends on phonon scattering and film inhomogeneities[5]



- Temperature-dependent PL shows more redshifted, sharper and more intense emission at low T

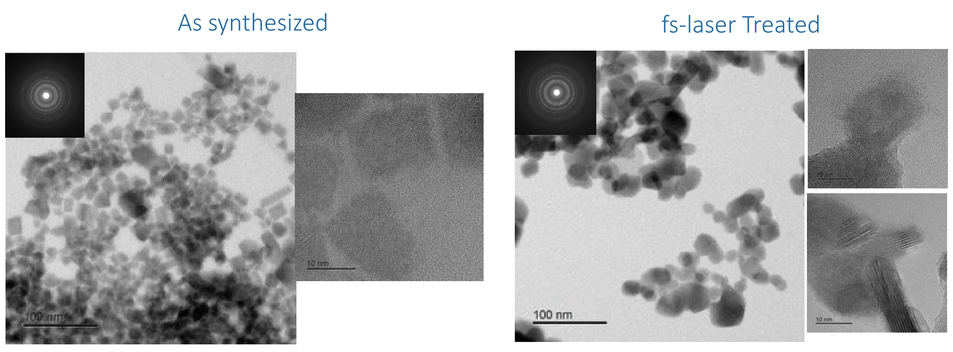


- Stronger redshift at low T can be explained by lowest energy exciton levels splitting due to dipole-dipole interaction between neighboring QDs[6]



Analysis II

- TEM shows a mild treatment rounds up the particles with signs of amorphous surface, some elongated structures appear



- The stability to humid environment and PL of films can be explained by a resulting more compact QD film

to be continued

結論 – Conclusions

I.
- a) Films of $FAPbI_3$ QDs synthesized with 1-Octene show higher PLQY, exciton delocalization and weaker phonon coupling
- b) QDs-only PV cells show improved P_{CE}, V_{OC}, J_{SC} but worse FF than 1-Octadecene counterparts

II.
- a) fs-laser treatment on $FAPbI_3$ QD colloids turns the particles rounder than the untreated.
- b) Films of these SE-QDs are more compact and show signs of energy exchange.
- c) SE-QDs as adlayers to bulk $FAPbI_3$ films improve slightly the V_{OC} of PV cells and significantly the resistance to exposure to humidity.

参考文献 – References

1. Xue et al. – *Joule* 2, 1866-1878 (2018)
2. Rocks, C. et al. – *Nano Energy* 50, 245-255 (2018)
3. Svrcek, V. et al. – *J. Phys. Chem. C* 120, 18822-18830 (2016)
4. Woo, H. C. et al – *J. Phys. Chem. Lett.* 9, 4066-4074 (2018)
5. Fu, M. et al – *Nat. Commun.* 9, 1-10 (2018)
6. Blach, D. D. et al. – *Nano Lett.* (2022)

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