

The power of optical spectro-microscopy in the realm of energy materials

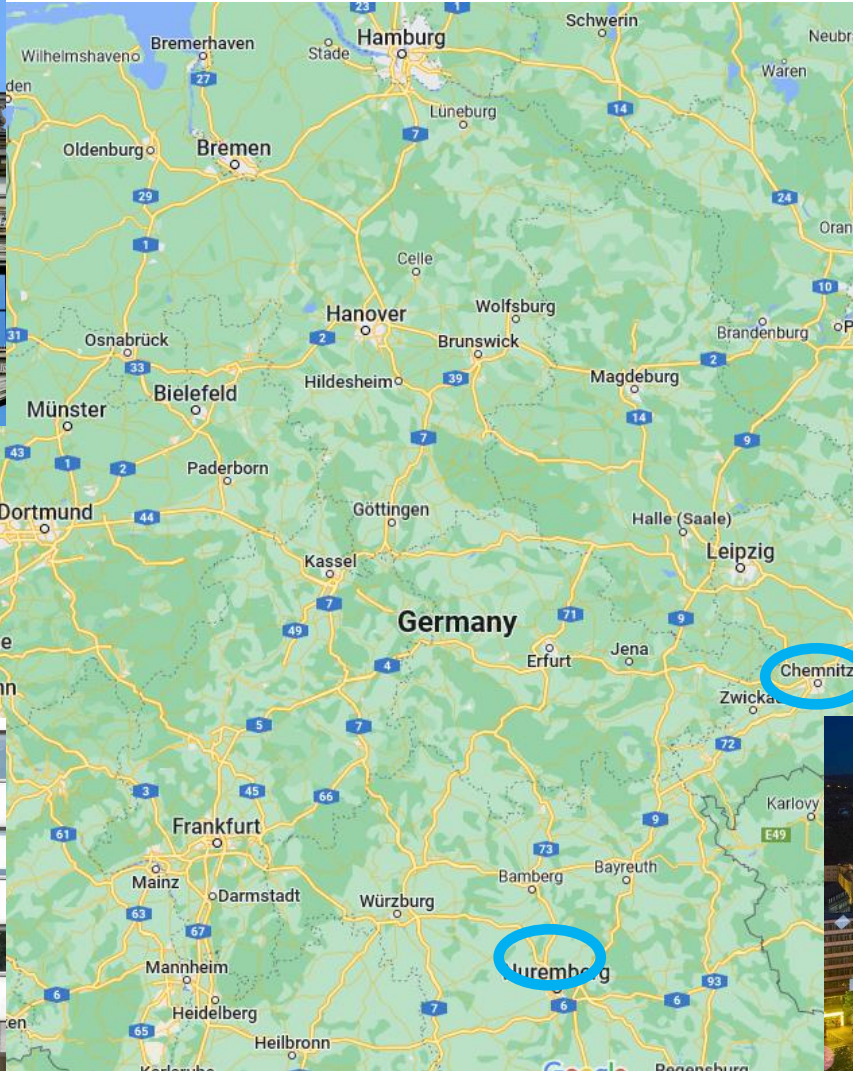
Simon Kahmann

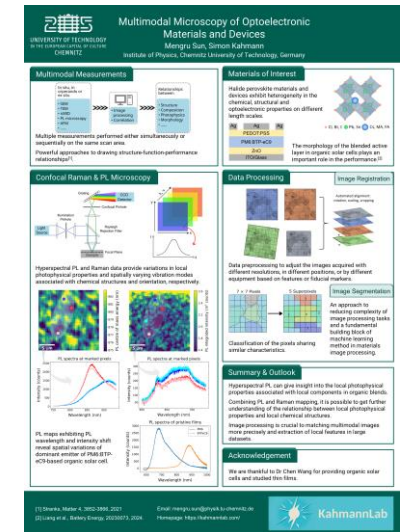
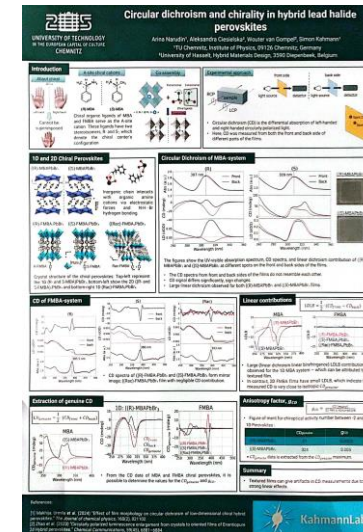
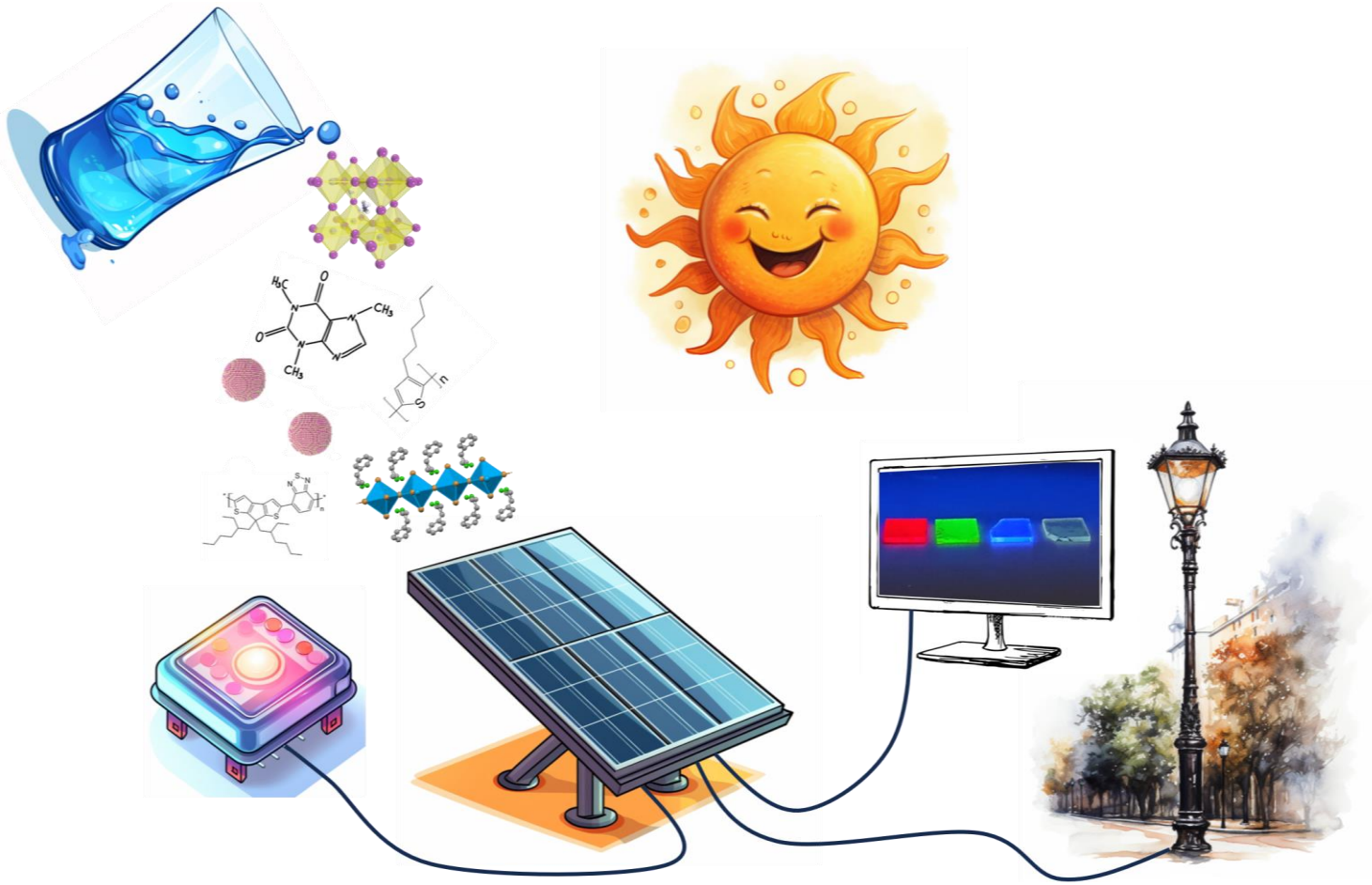


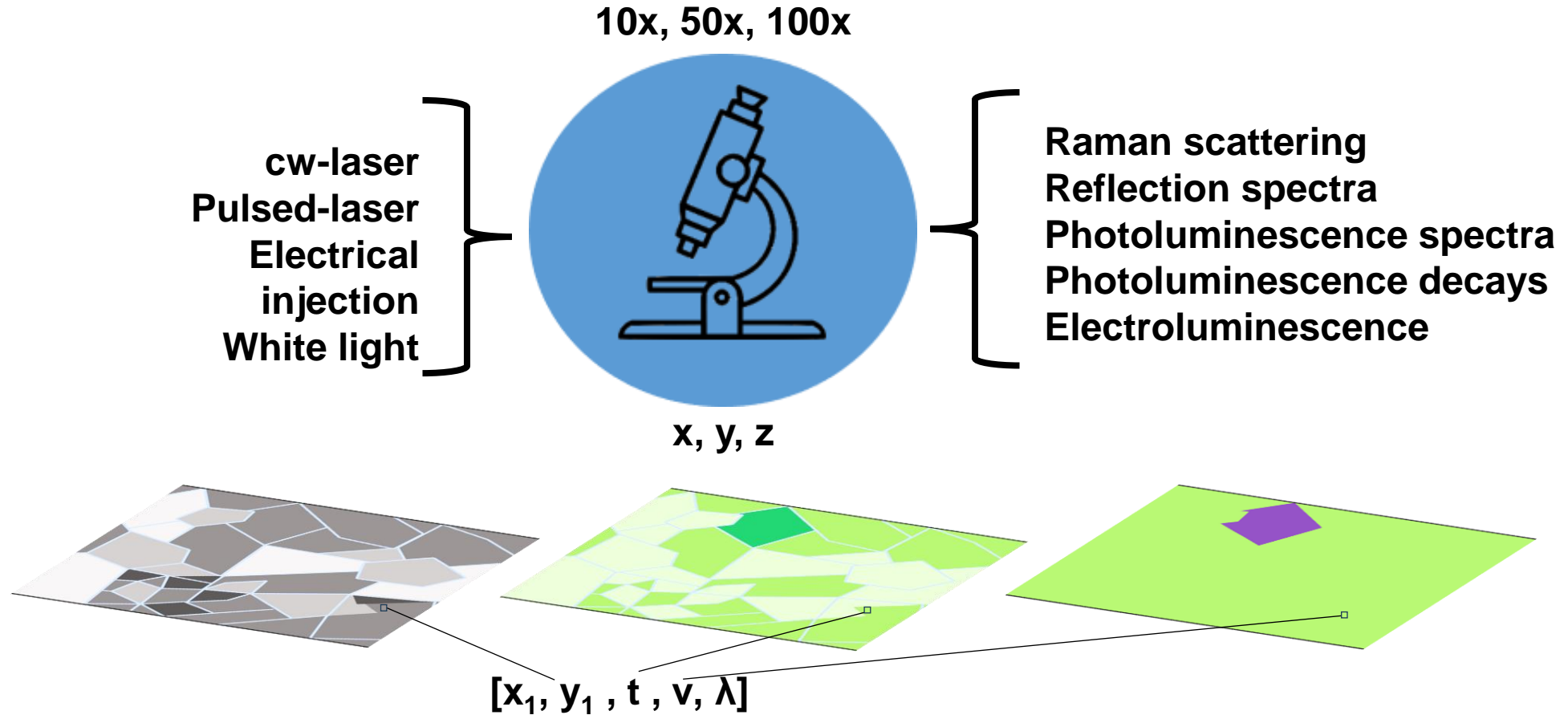
simon.kahmann@physik.tu-chemnitz.de
@skahmn



Established 1836







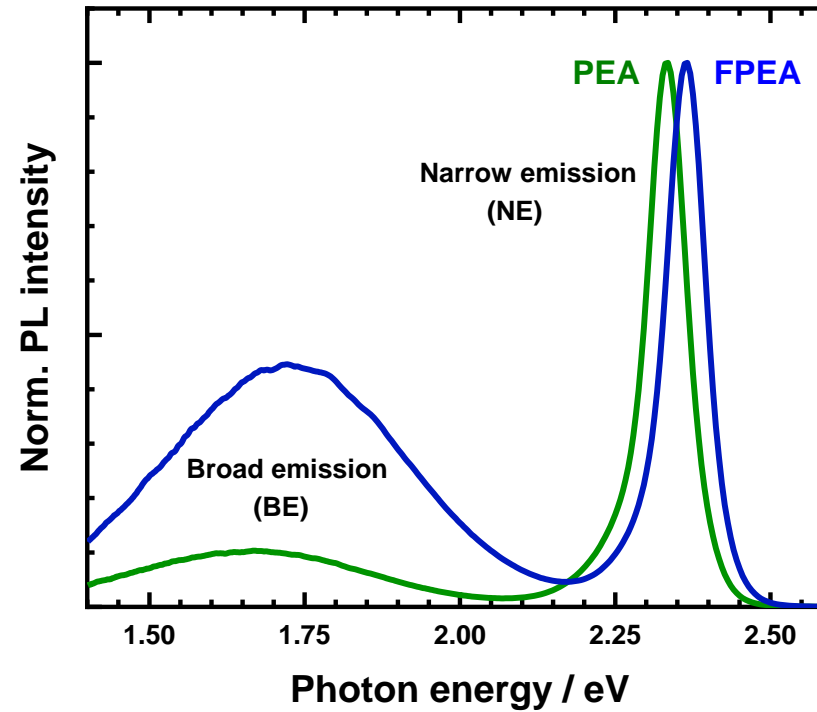
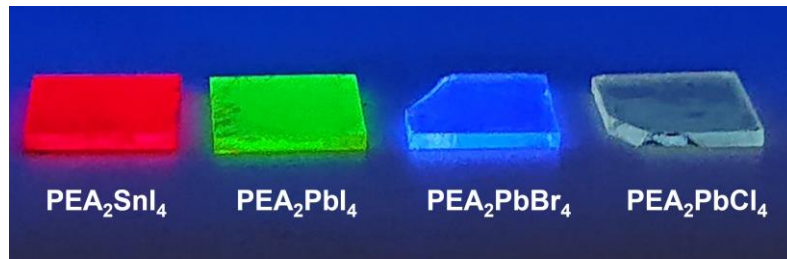
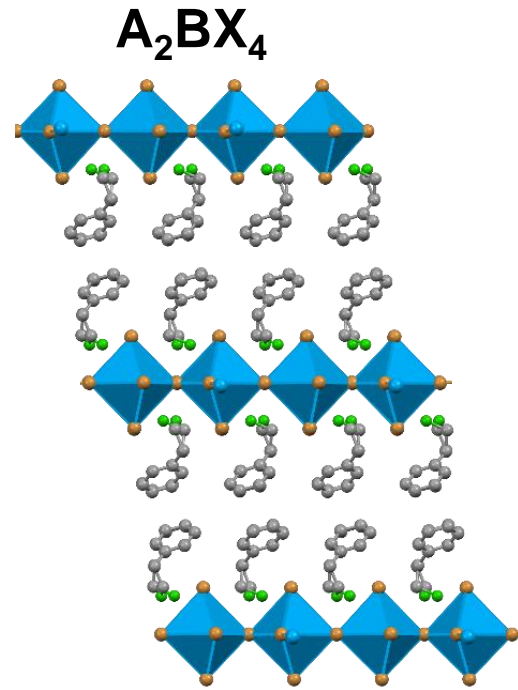
PL spectroscopy is pretty groovy

Microscopy comes in many great flavours

Problems and opportunities in optical microscopy

Photophysics of RP Perovskites

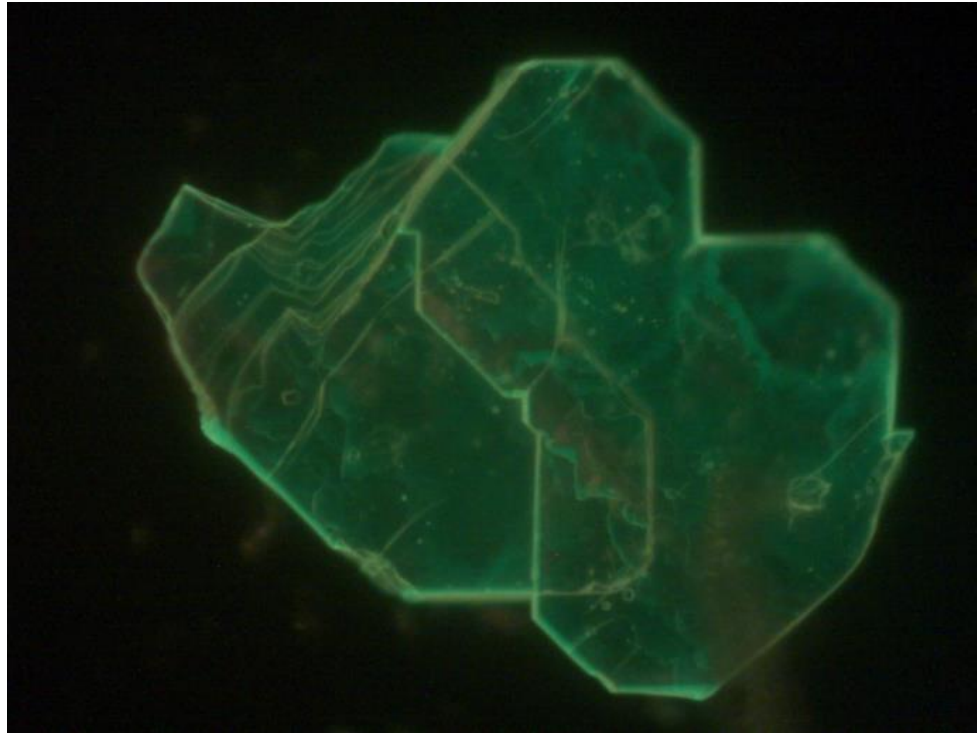
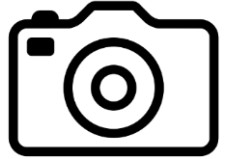
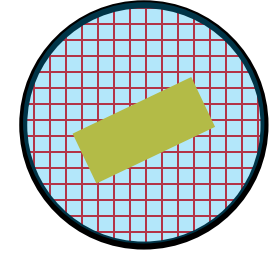
Insights from PL spectroscopy



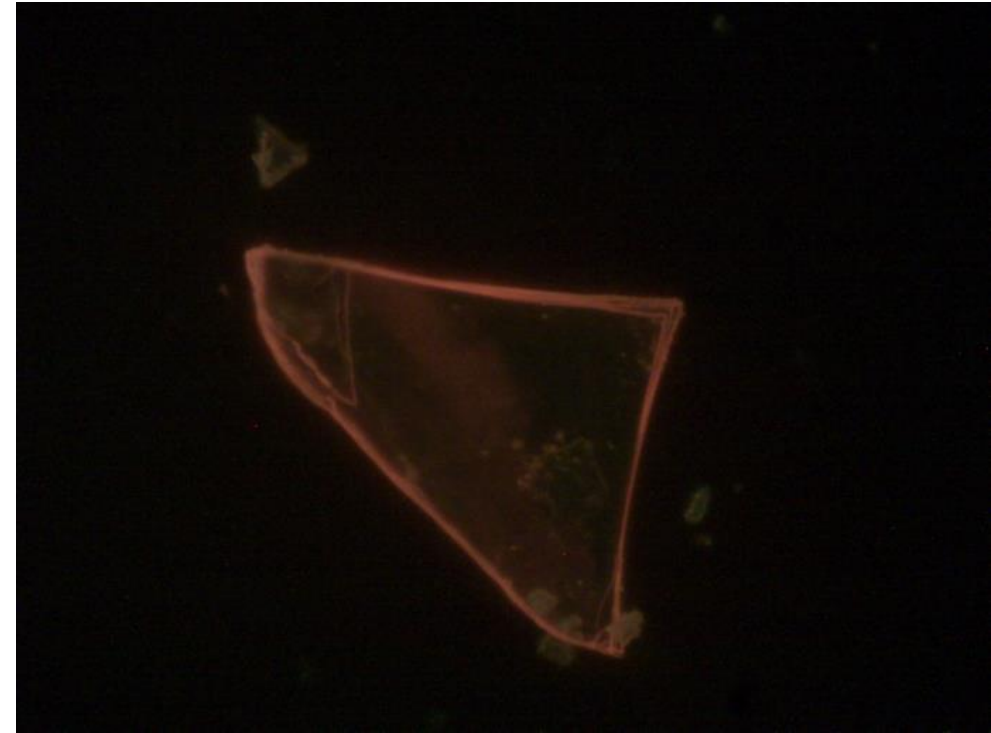
Eelco K. Tekelenburg

Kahmann et al., Nature Commun. 11, 2344, (2020)

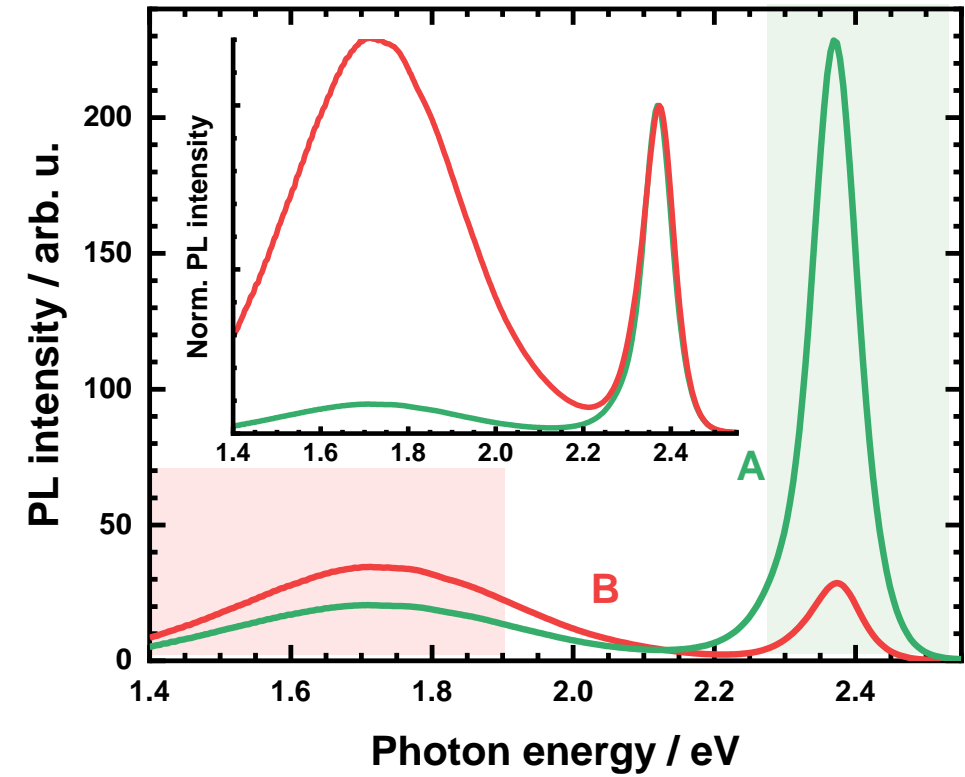
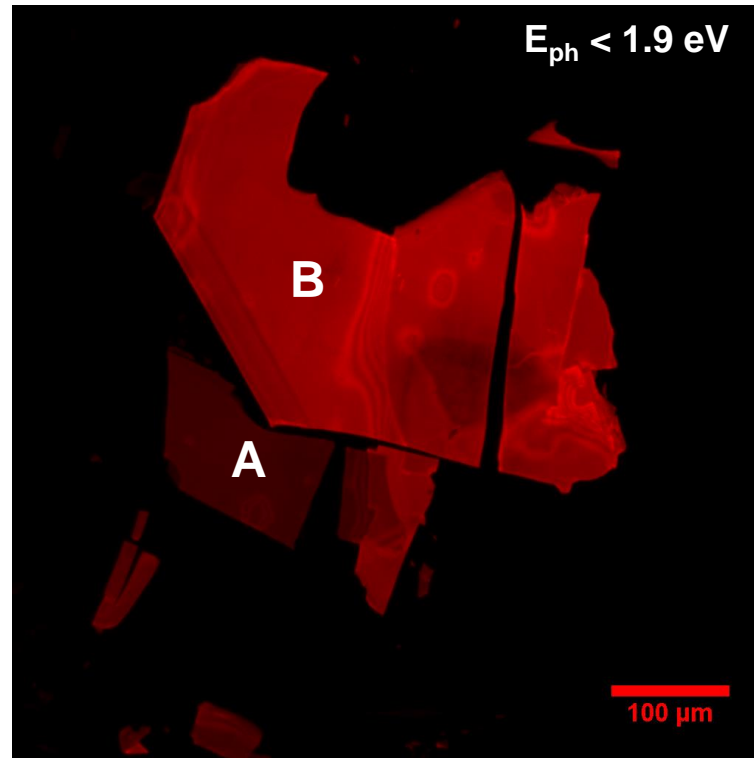
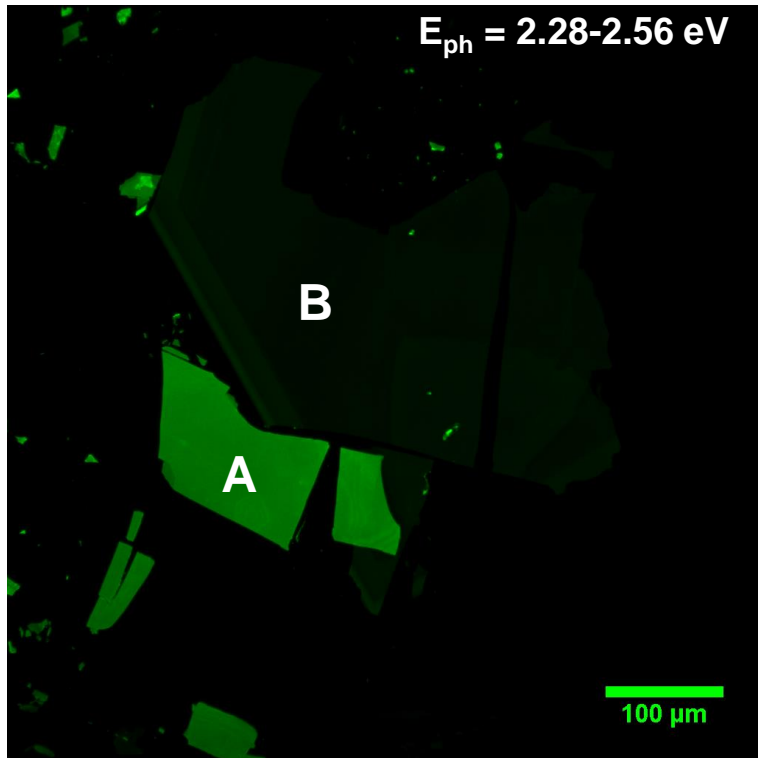
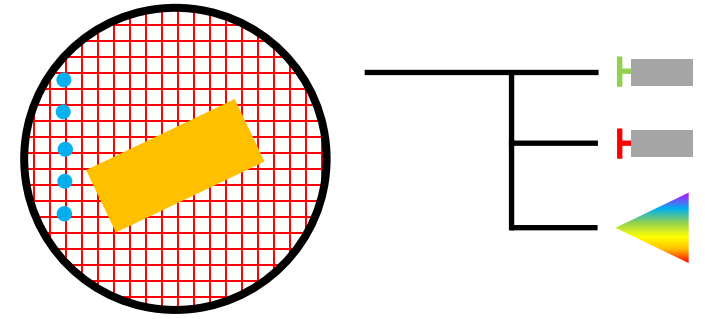
Tekelenburg, Kahmann et al., Adv. Opt. Mater., 2001647, (2021)

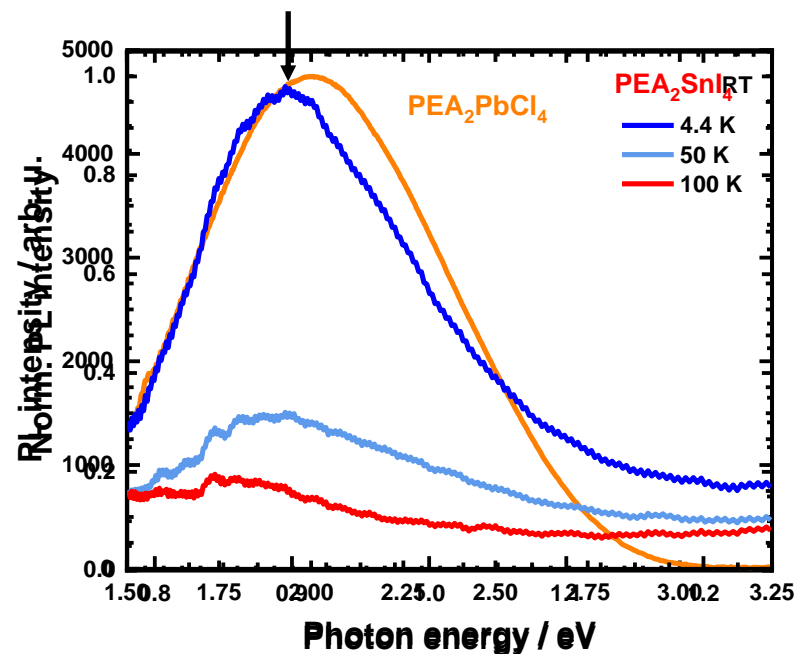
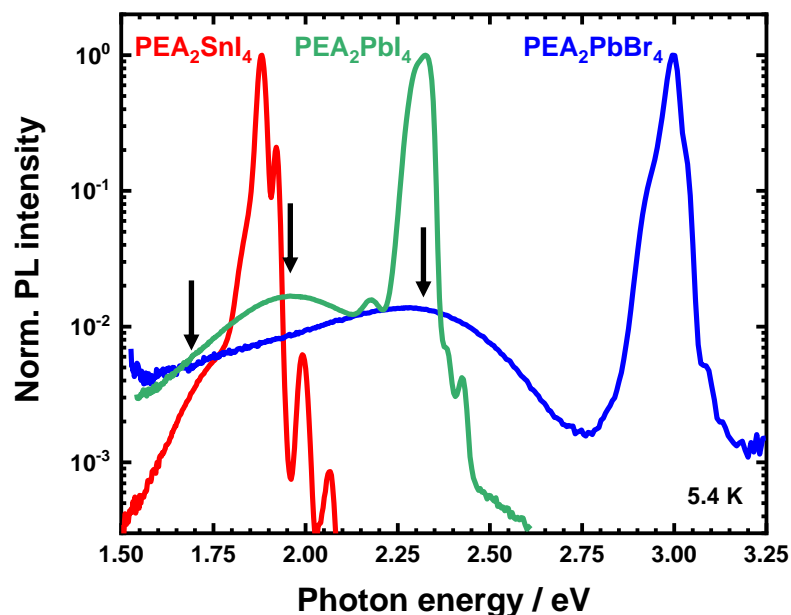


Green flake



Red flake

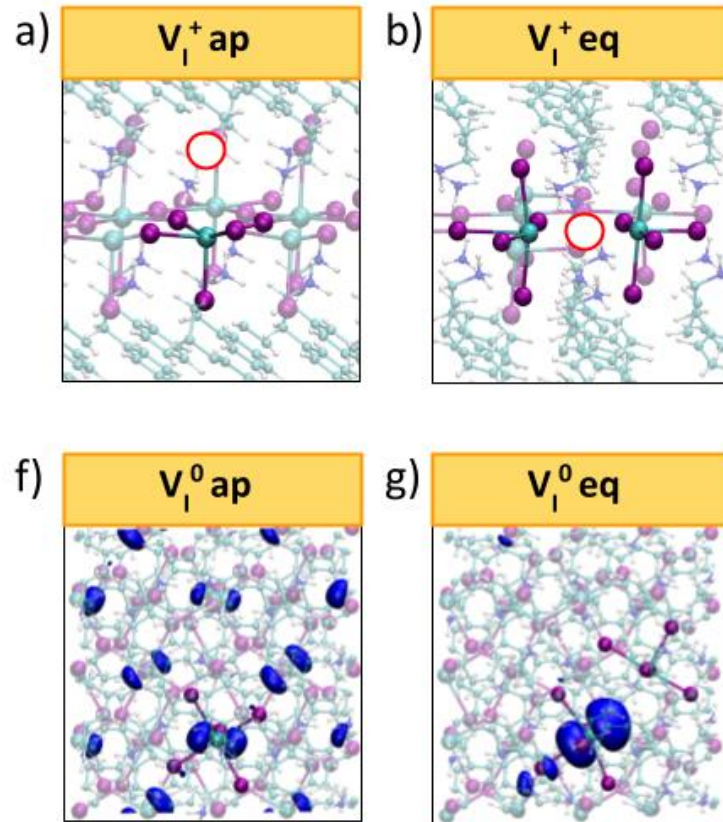




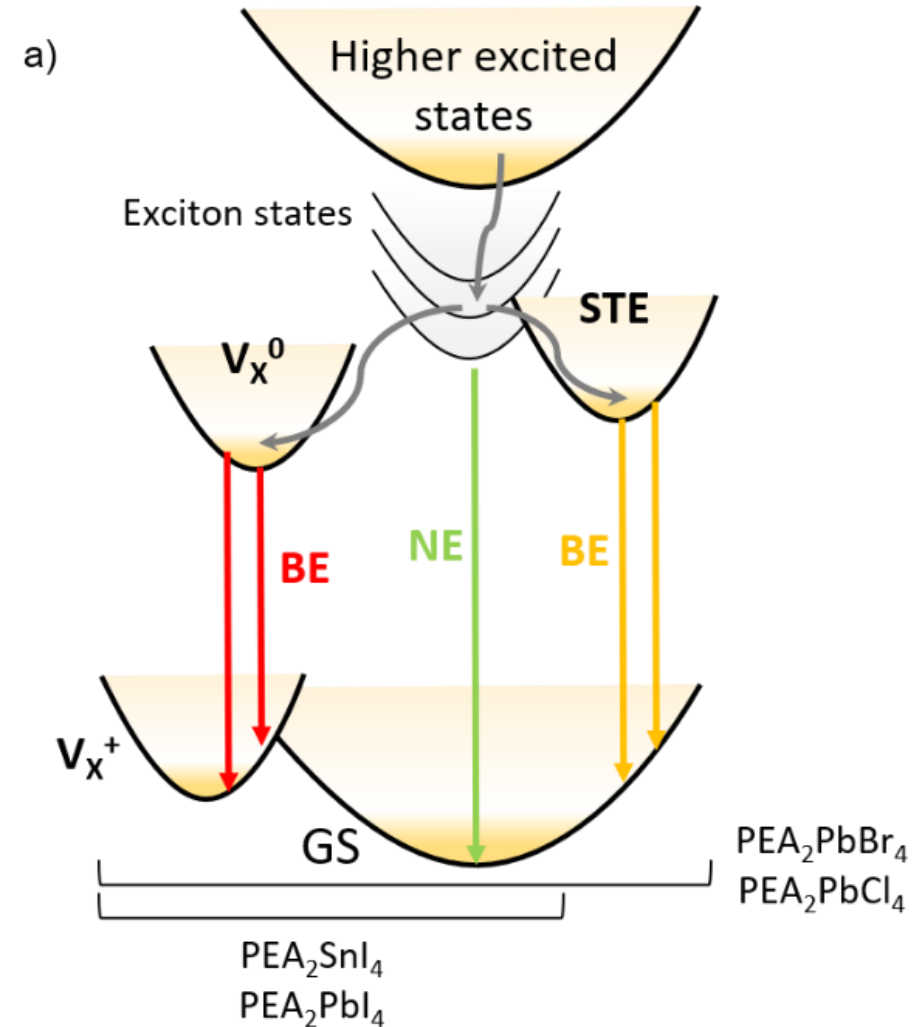
Material	Origin	PL emission Experiments / eV	PL emission Theory / eV
PEA ₂ PbCl ₄	STE		1.89
	V _{Cl} eq	2	1.97
	V _{Cl} ap		1.85
PEA ₂ PbBr ₄	STE	2.3	2.19
	V _{Br} eq	1.75	1.78
	V _{Br} ap		1.73
PEA ₂ PbI ₄	STE	-	-
	V _I eq	1.7(?)	1.27
	V _I ap	1.95	1.97
PEA ₂ SnI ₄	STE	-	-
	V _I eq	0.9	0.82
	V _I ap	1.7	1.75

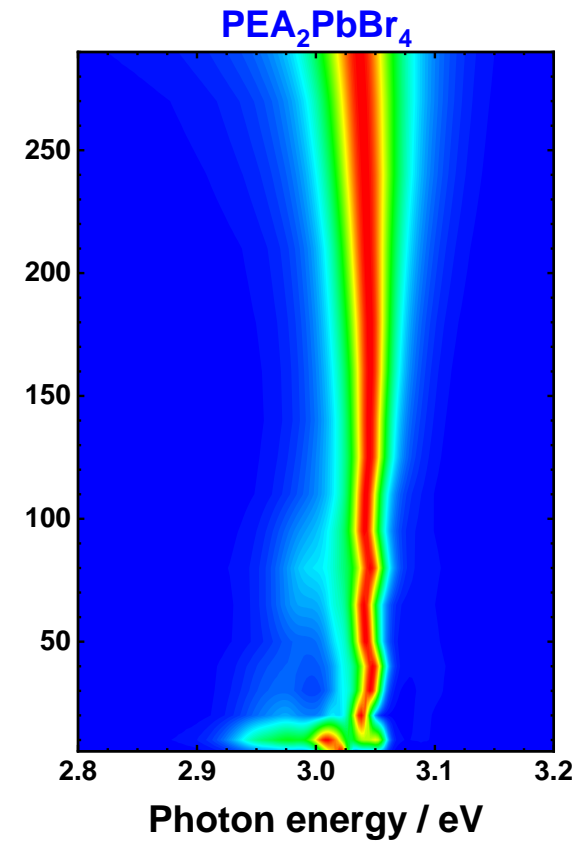
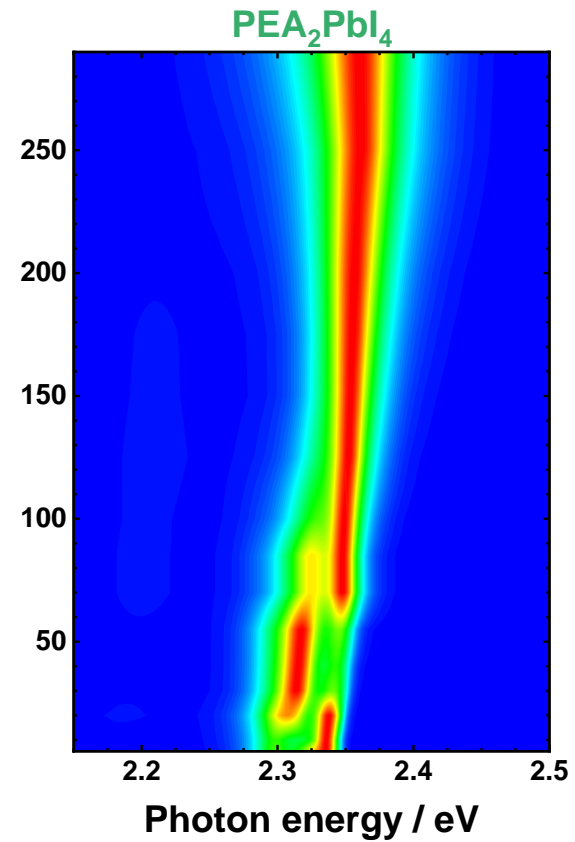
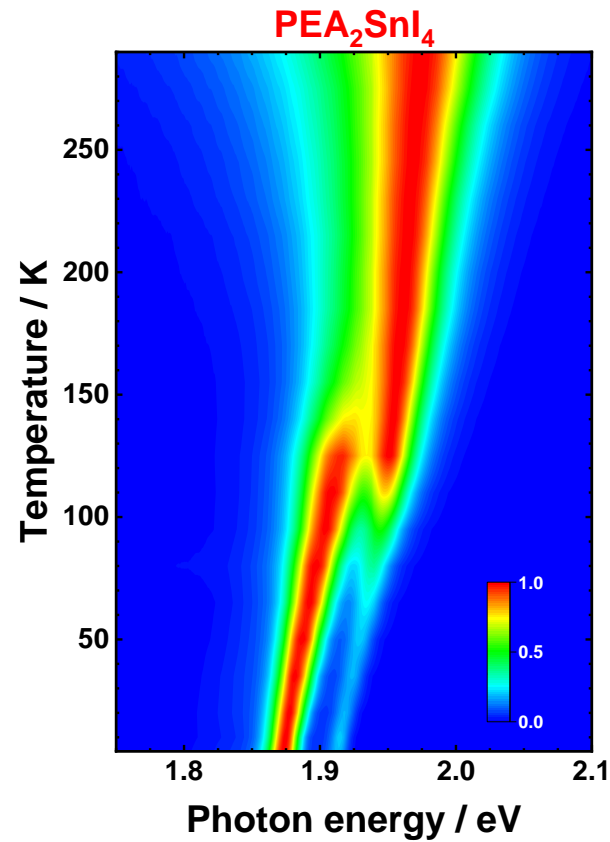
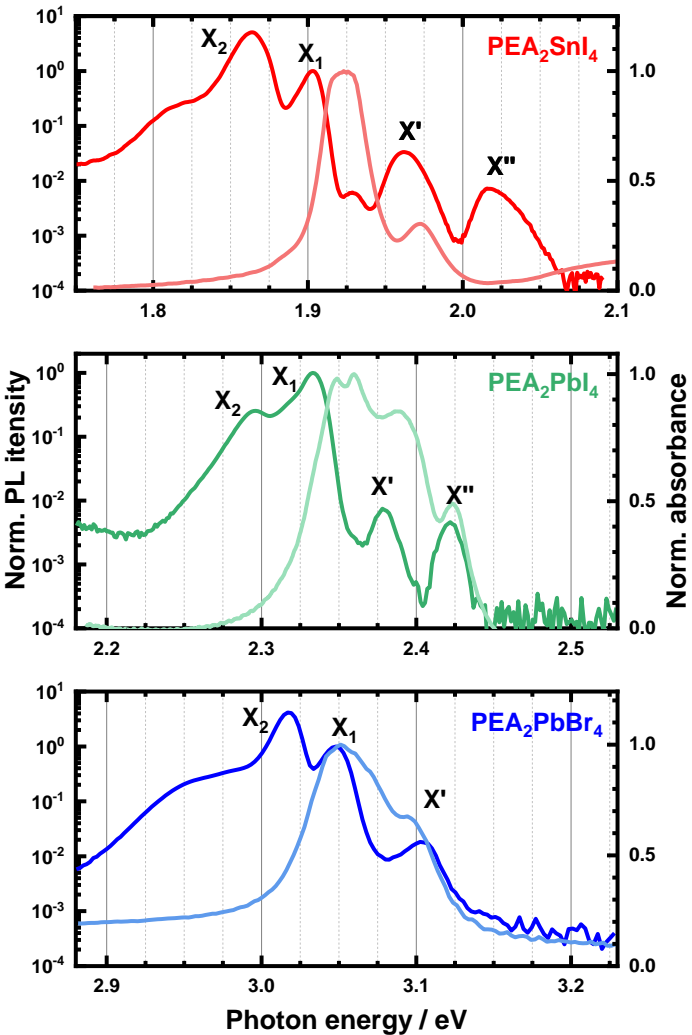
Overall great correspondence between BE and V_x-related prediction

The power of PL spectroscopy



$$V_X^0 + h^+ = V_X^{++} + h^*v$$

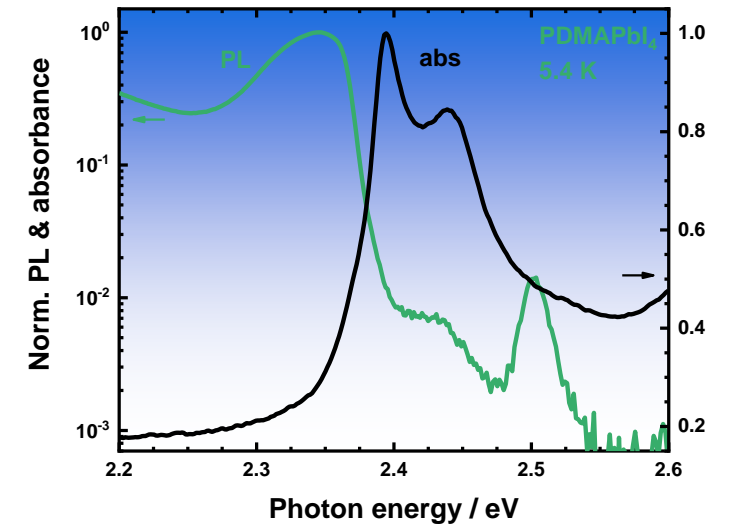
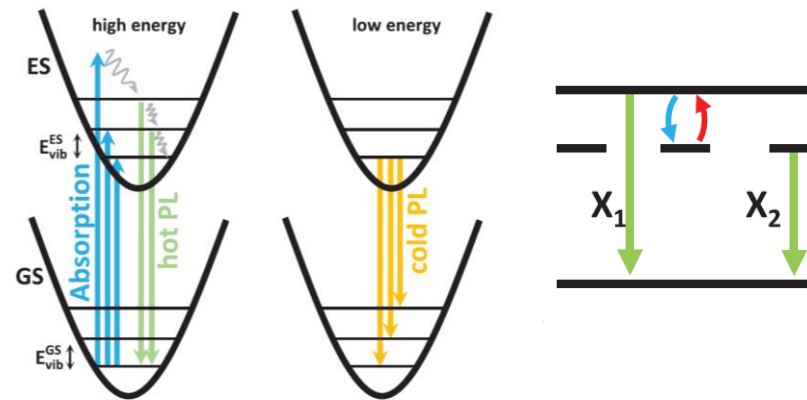
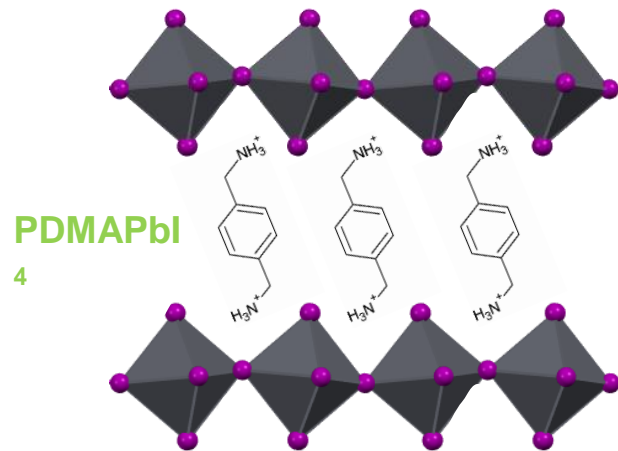
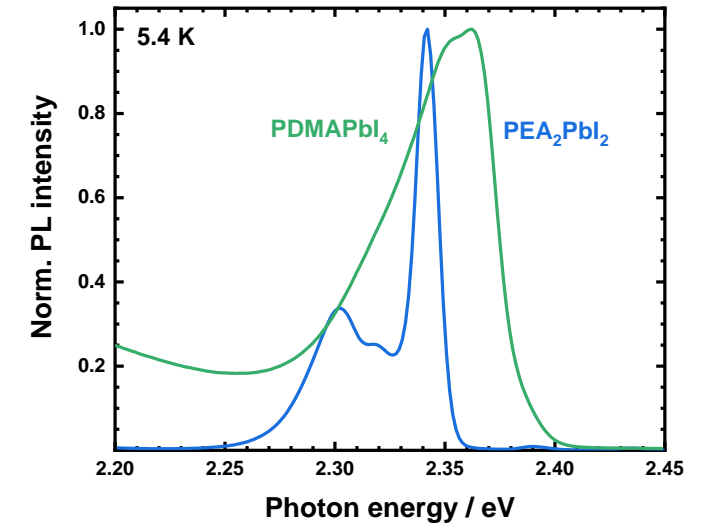
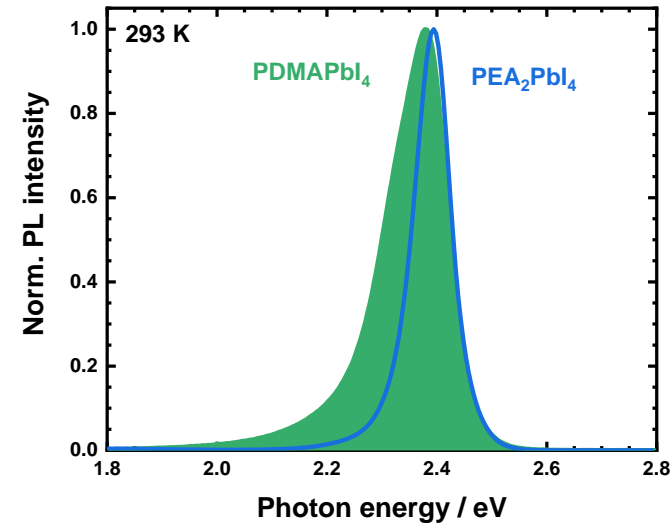
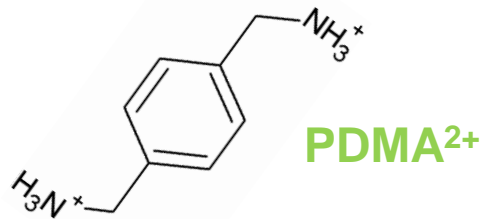




How about DJ compounds?

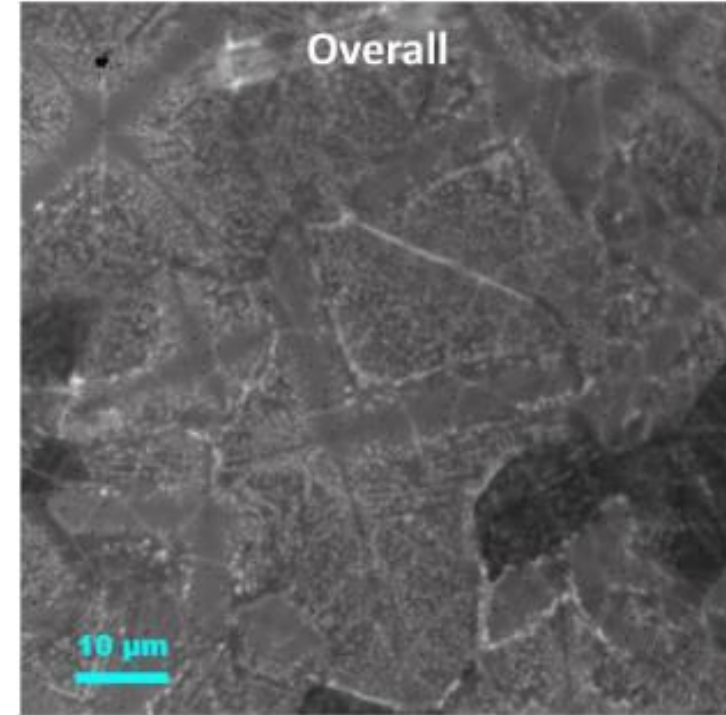
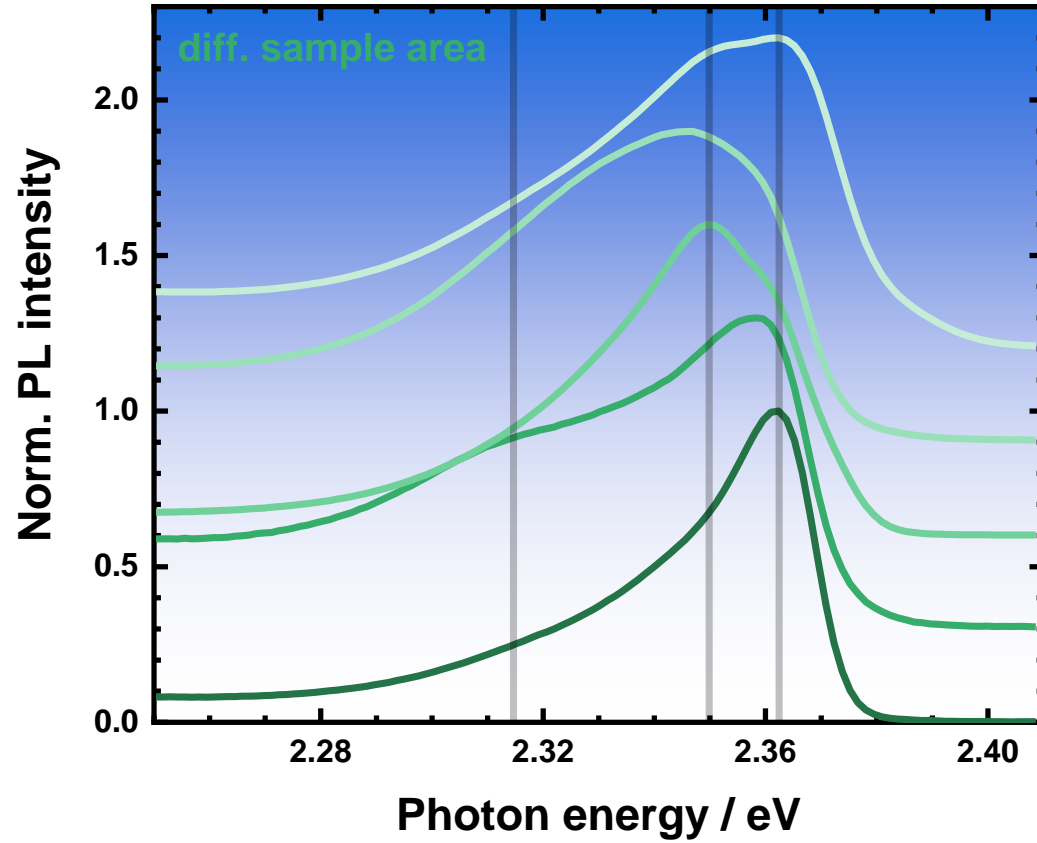
or why you need microscopes

Image formation in optical microscopy

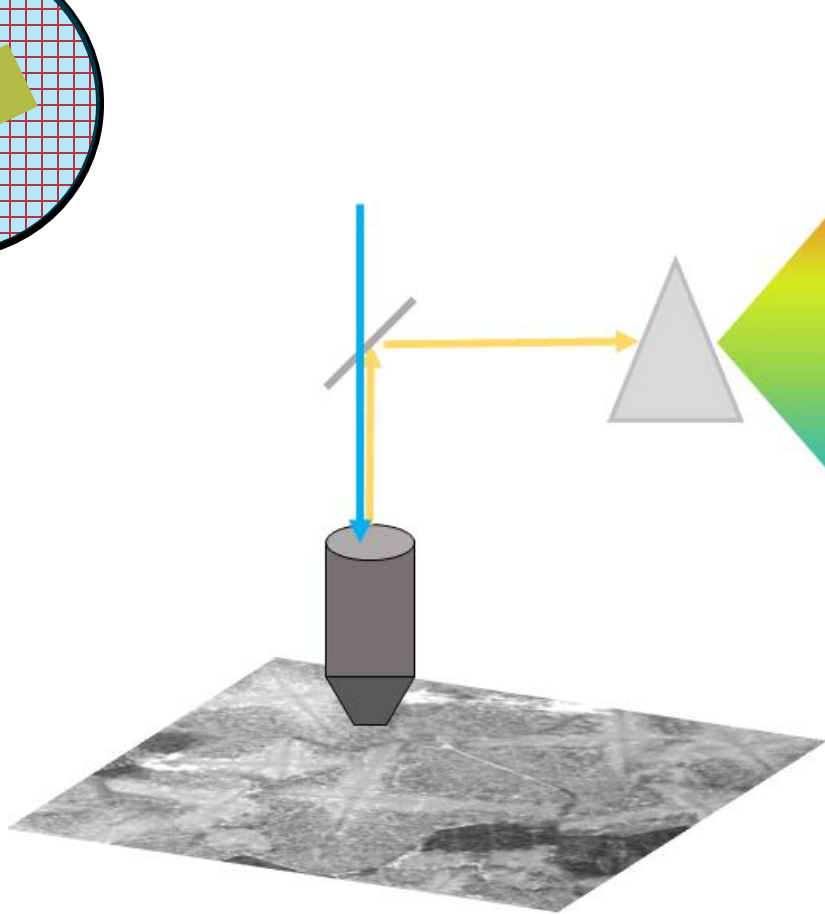
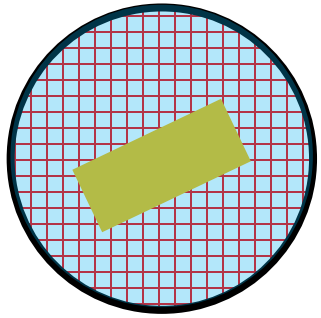




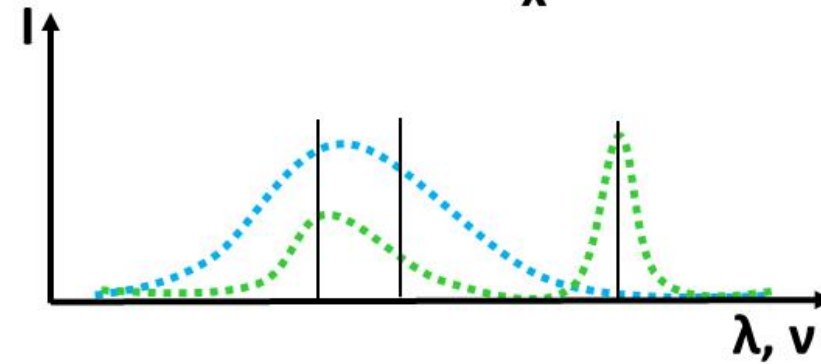
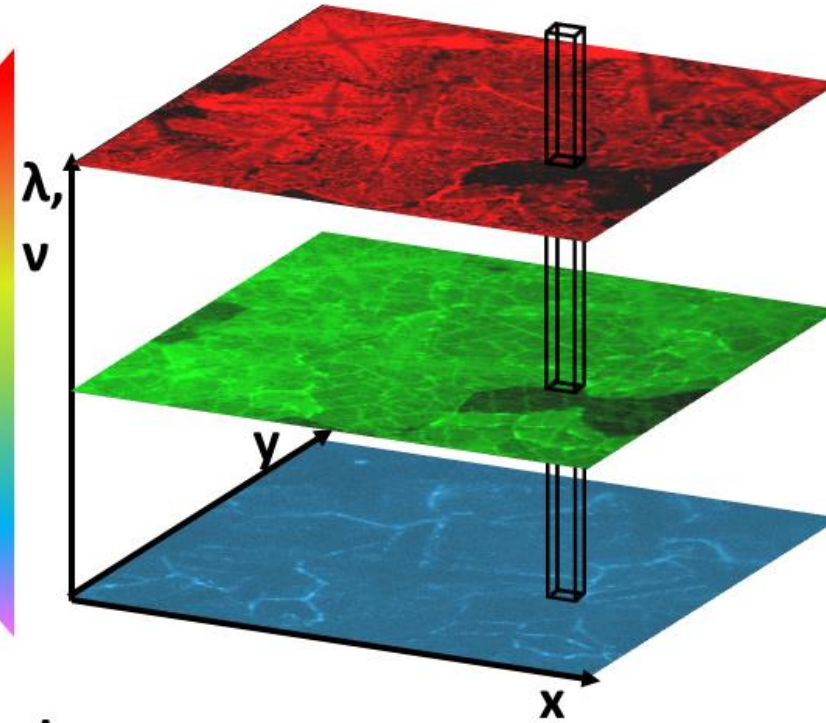
Herman Duim



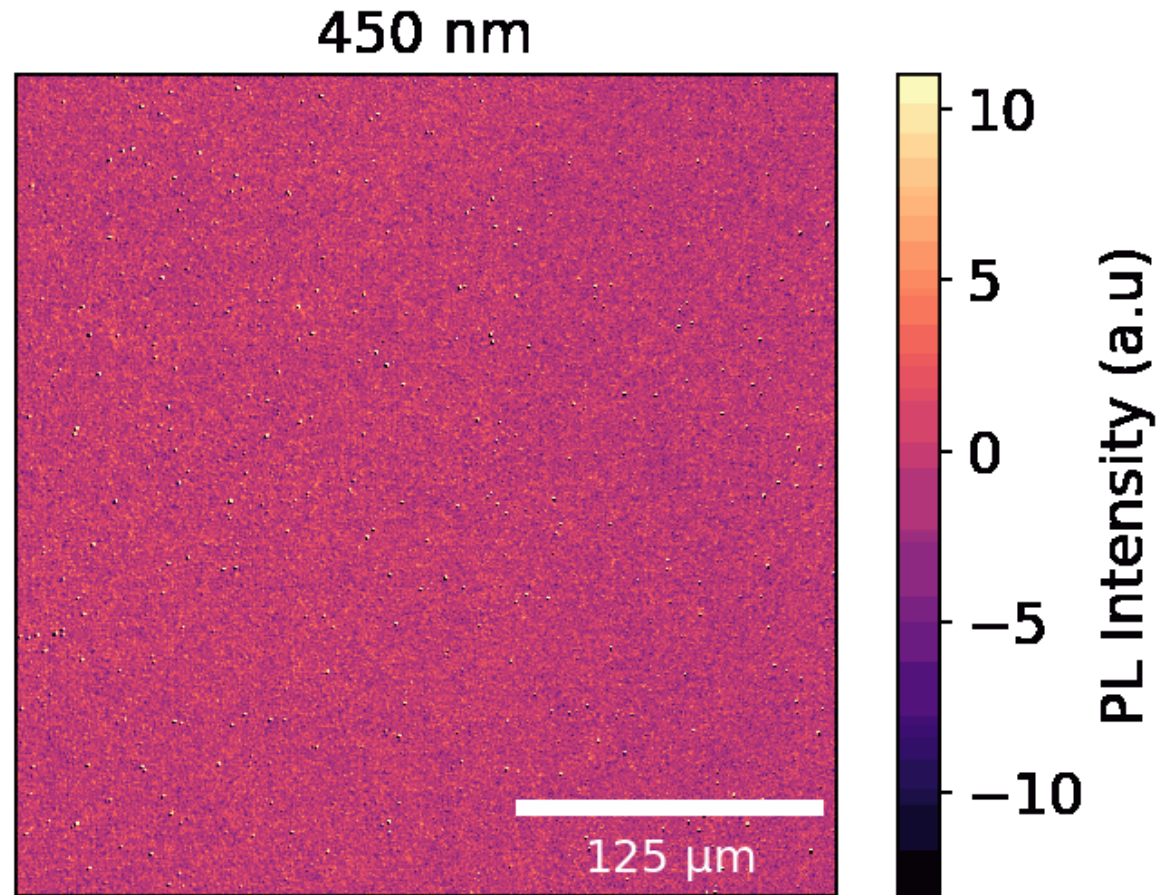
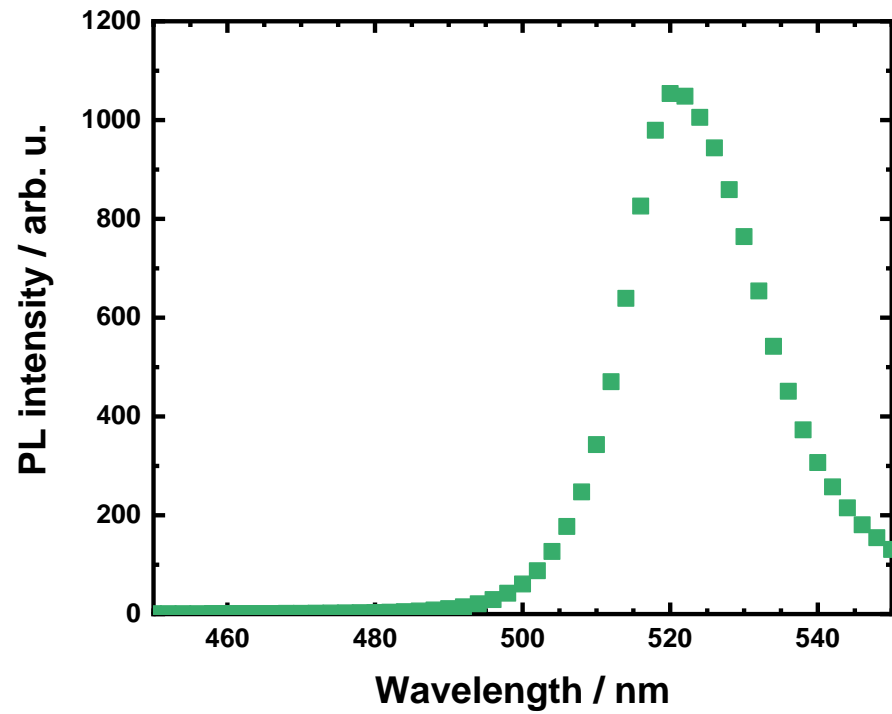
What's going on here??

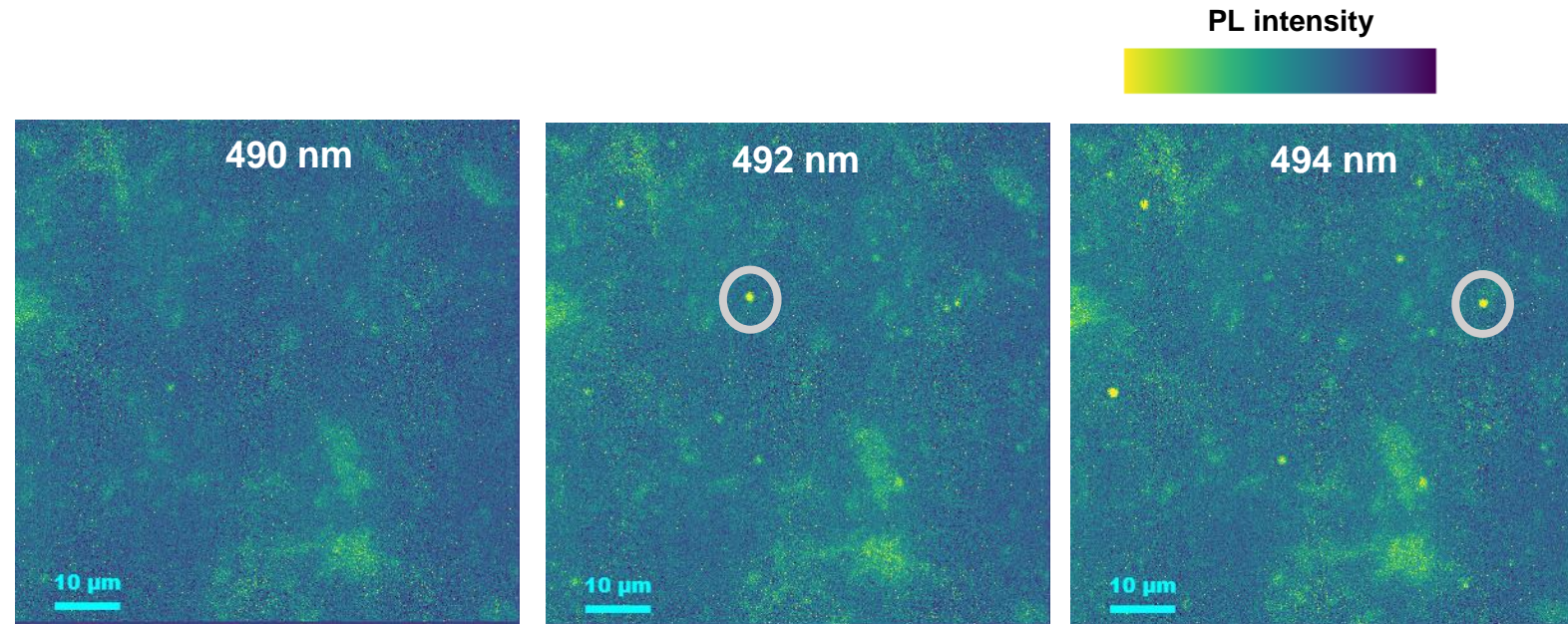
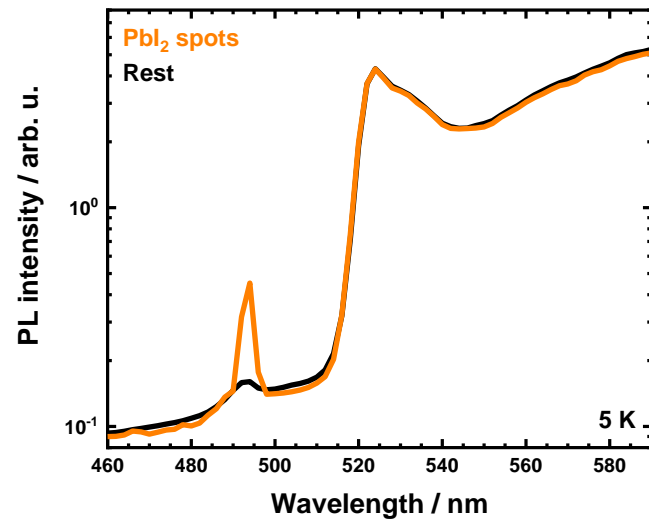
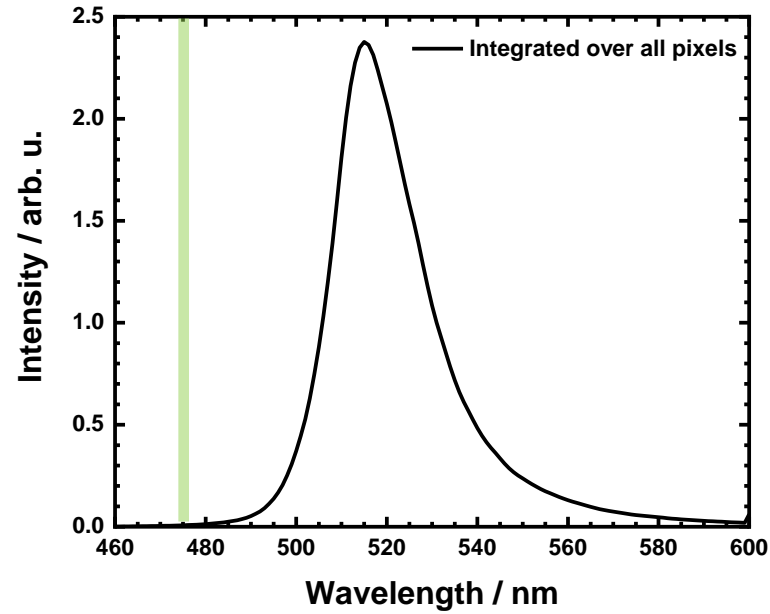


High spatial and spectral resolution



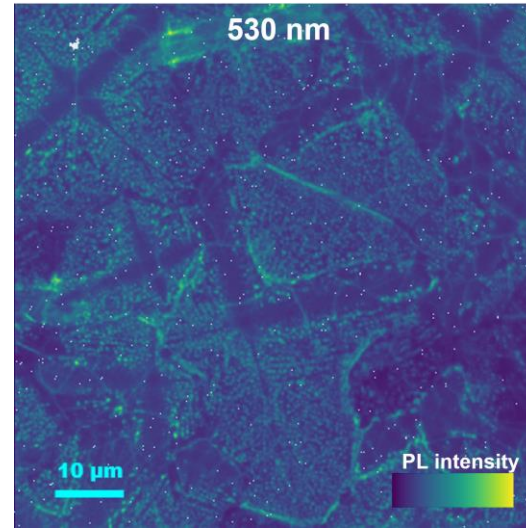
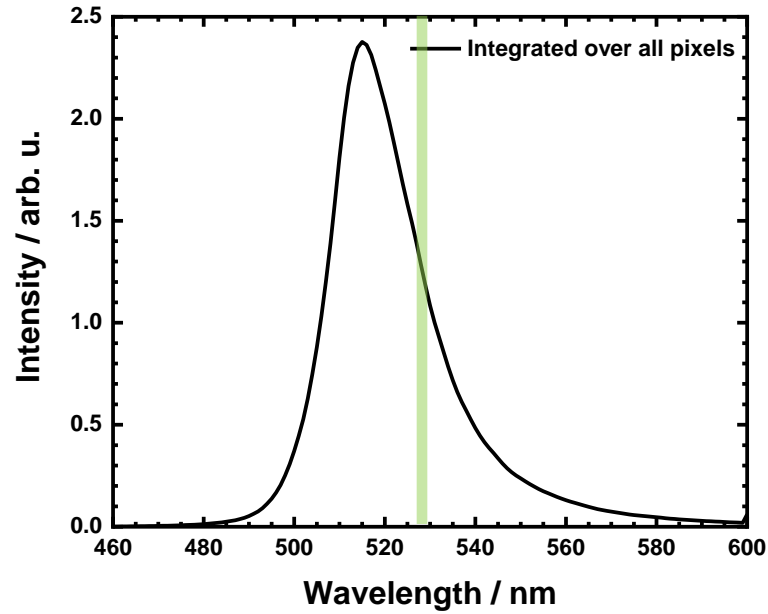
QFLS maps





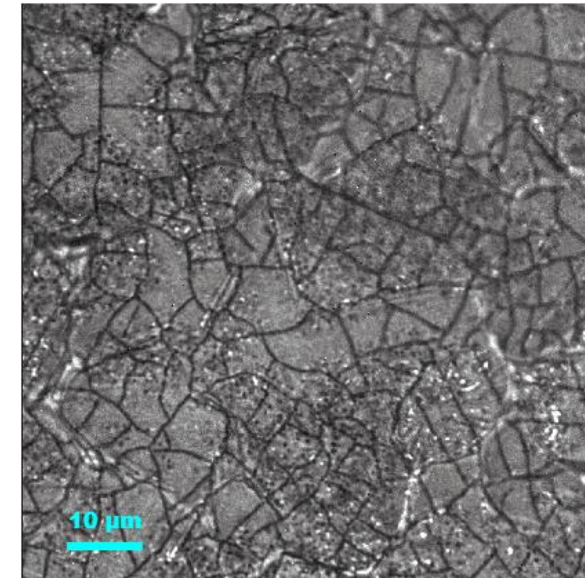
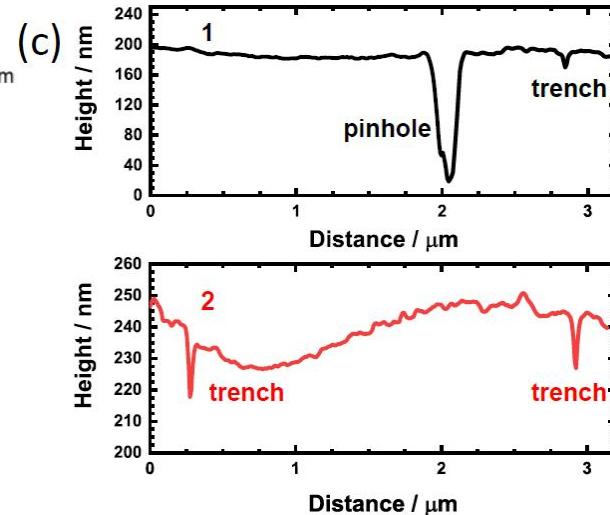
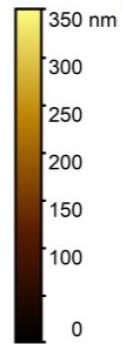
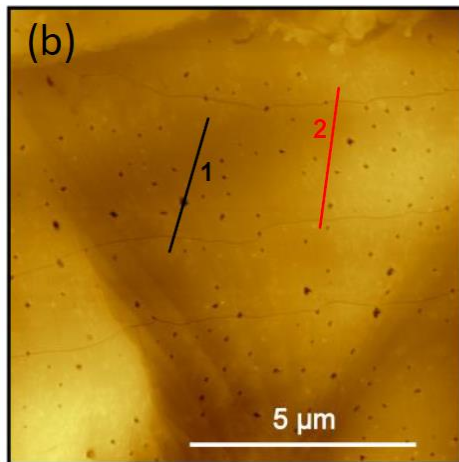
PbI₂ forms nanosized clusters
Not responsible for grain boundaries

Unravelling the emission



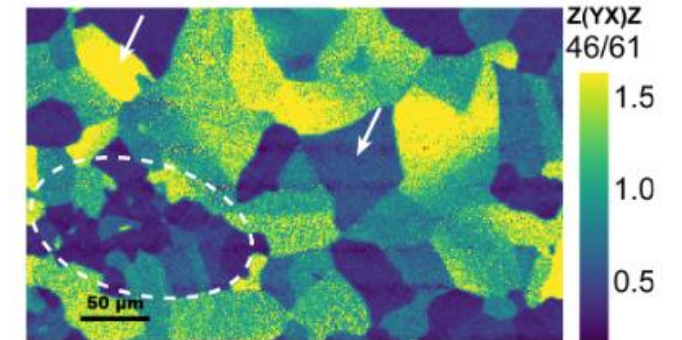
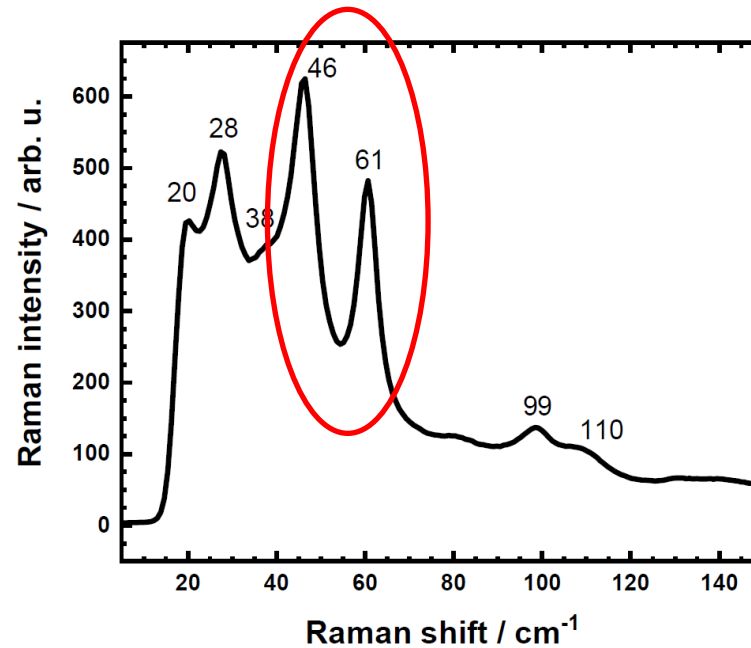
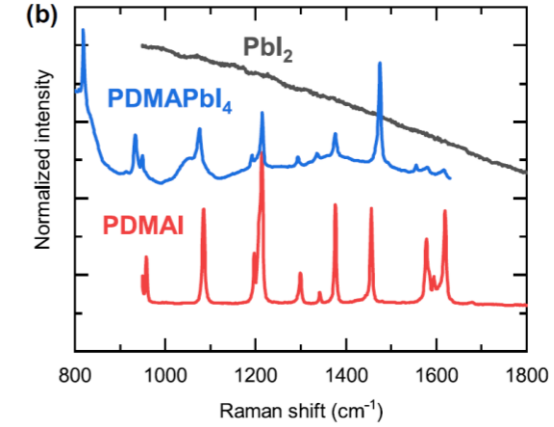
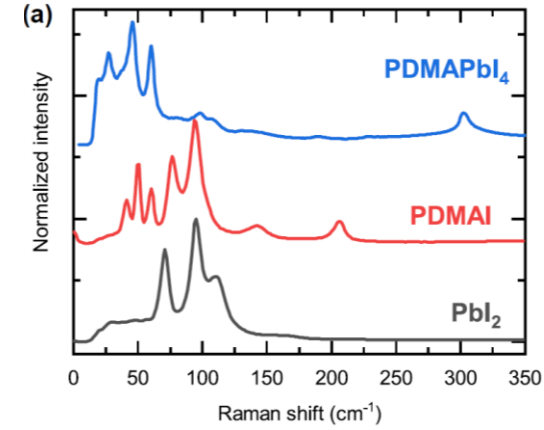
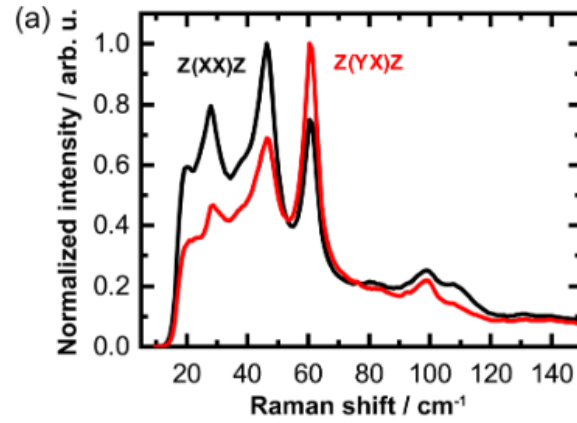
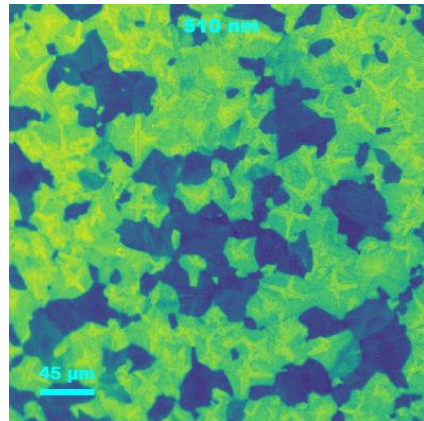
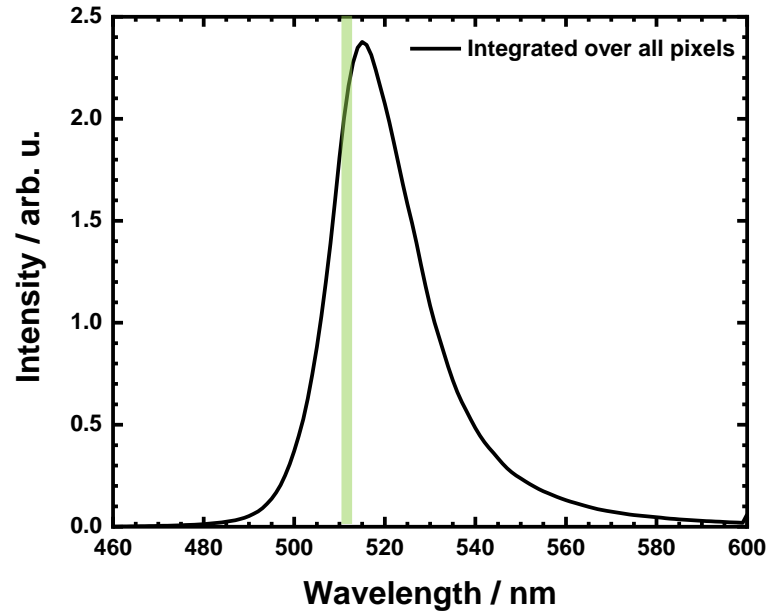
The film is riddled with trenches and pinholes

Facilitate outcoupling of photons; photon recycling results in red-shift

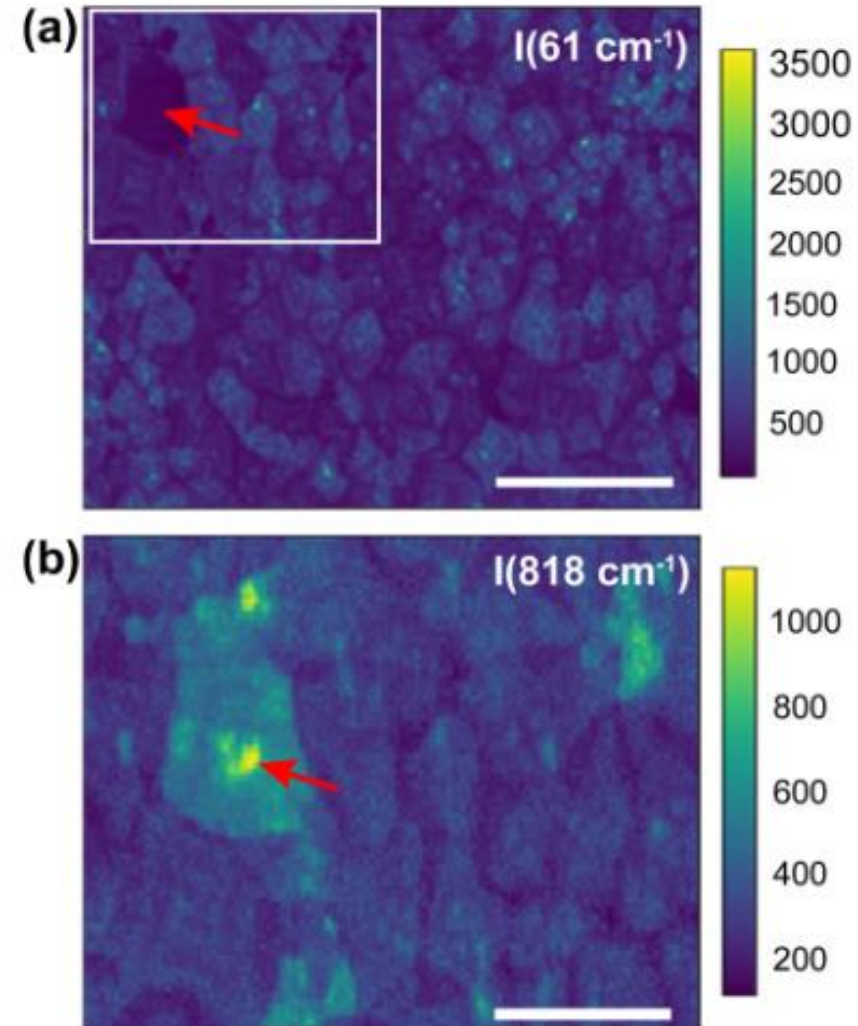
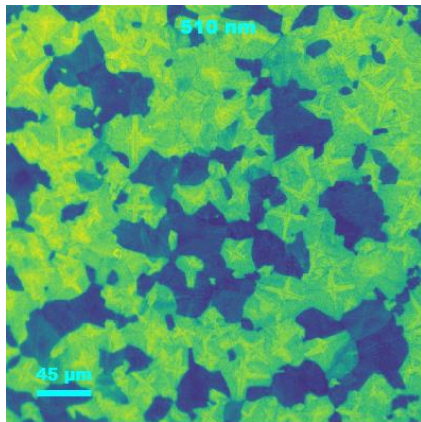
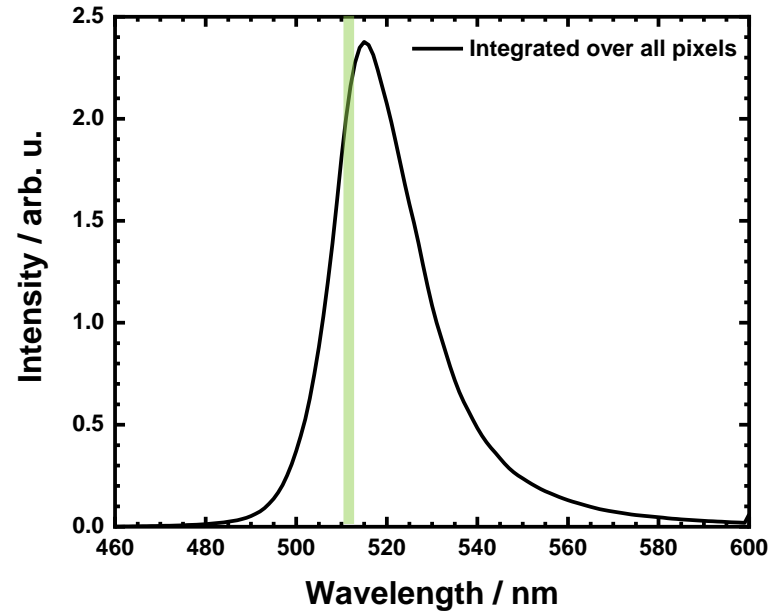


White light reflection

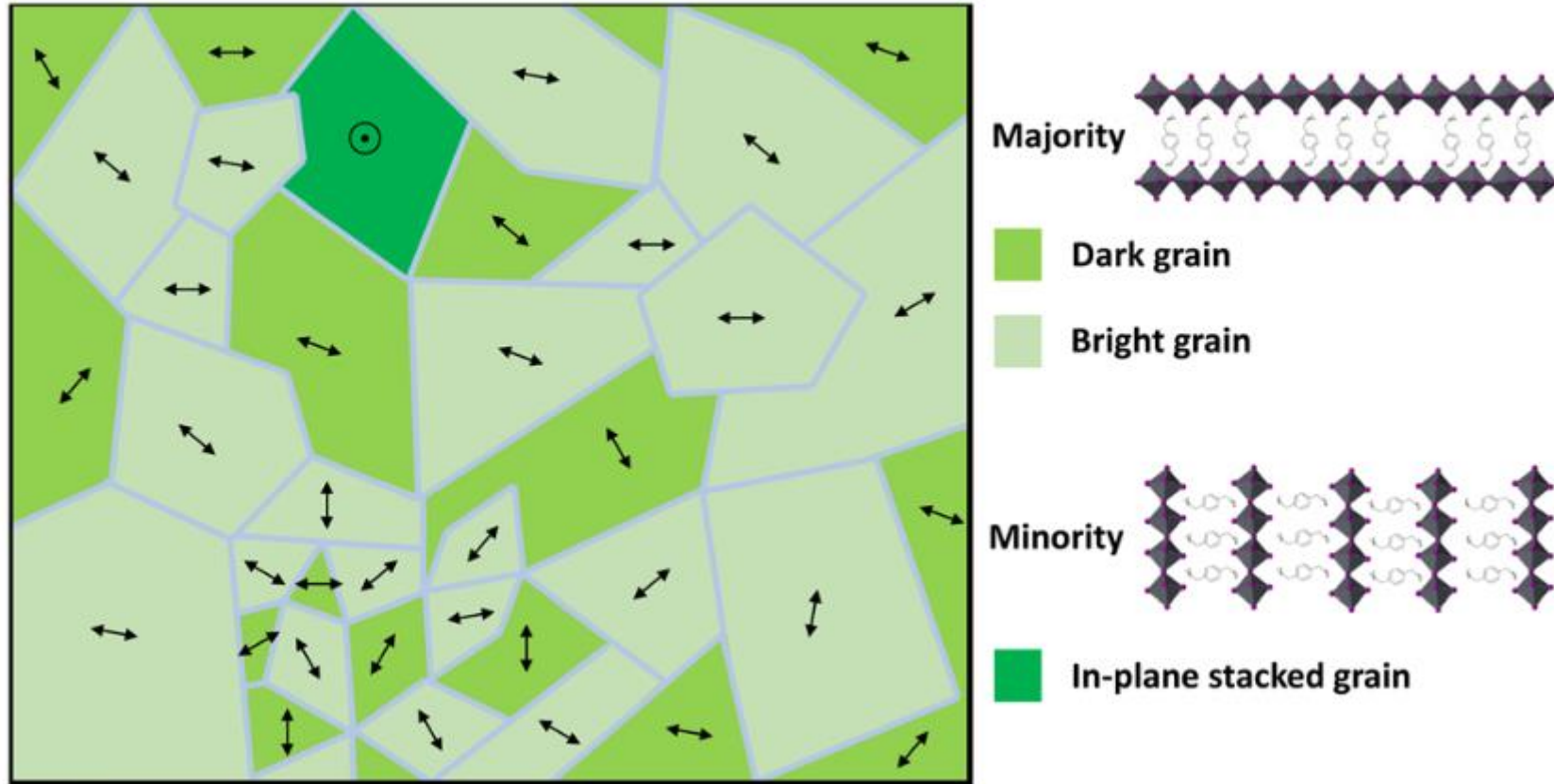
Raman resolves the orientation



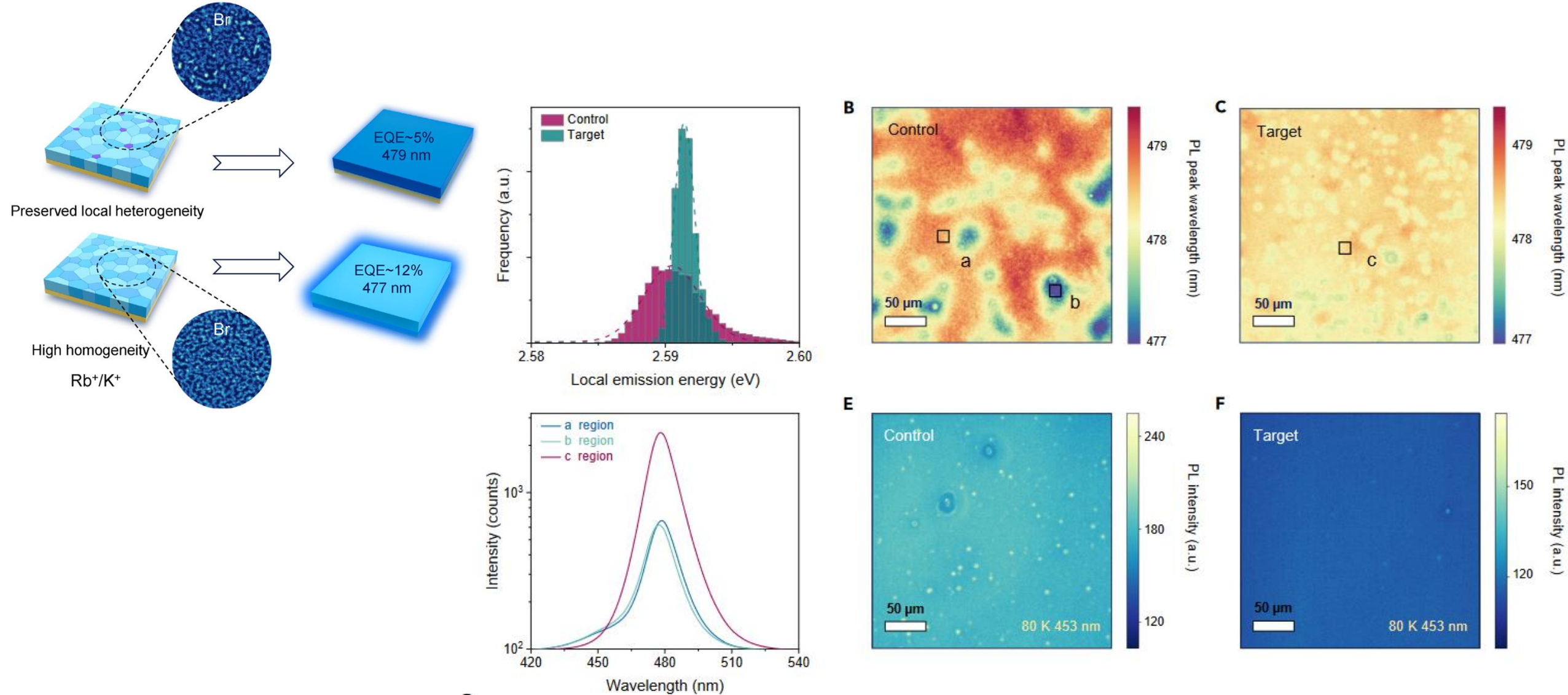
Raman resolves the orientation



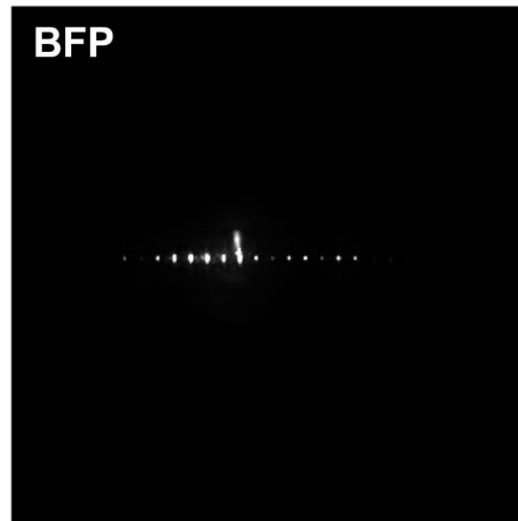
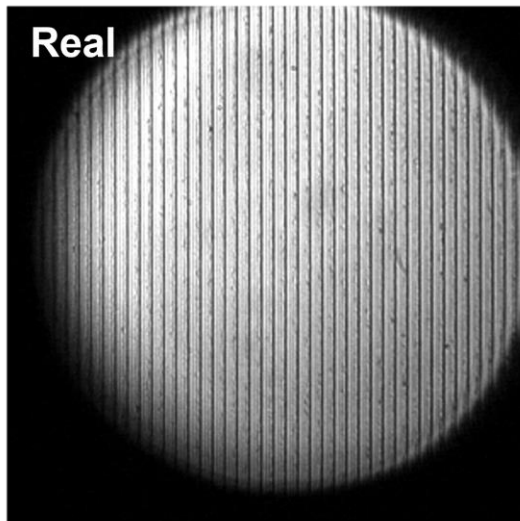
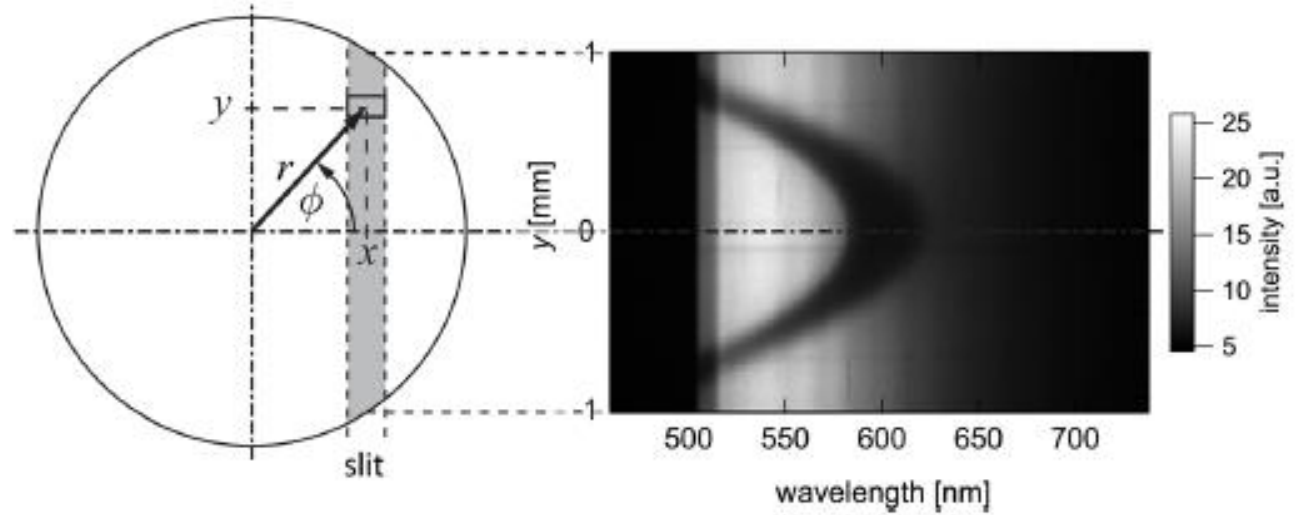
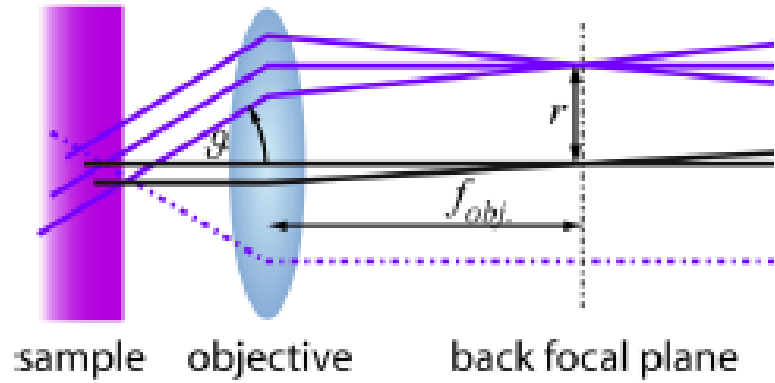
Crystalline orientation in the DJ film



Homogeneity in blue emitters for LEDs



Back focal plane imaging and spectroscopy

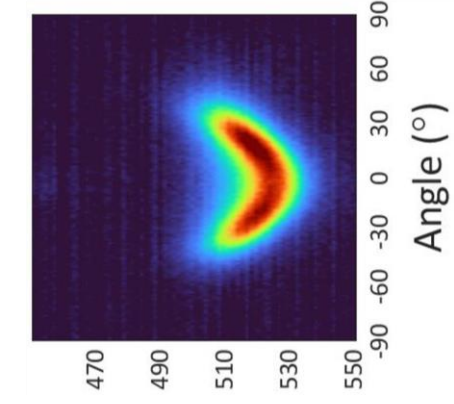
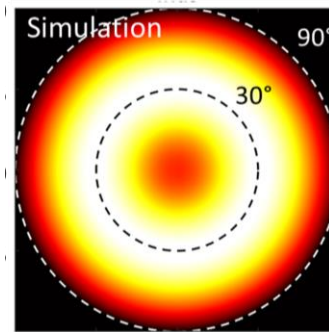
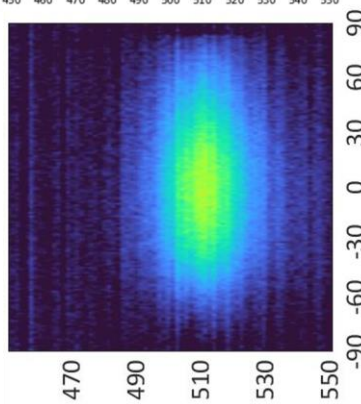
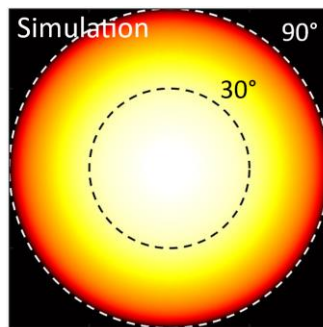
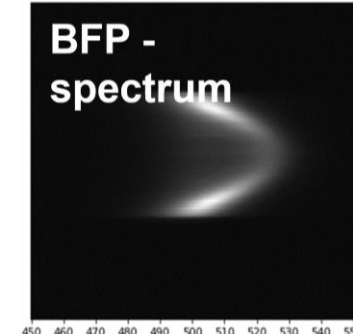
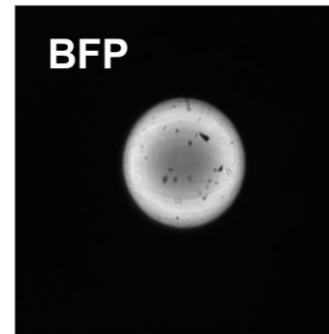
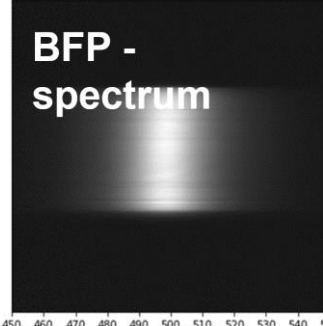
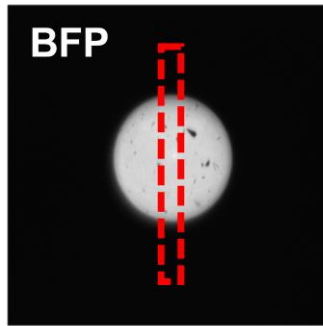
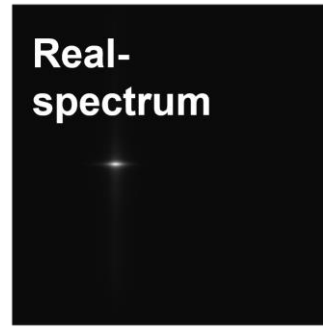
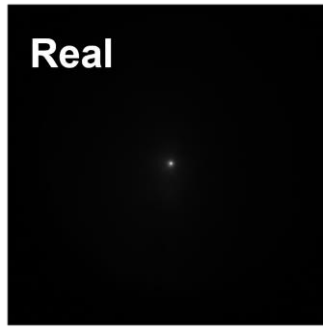
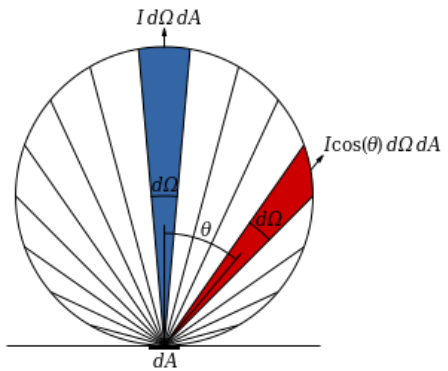


also known as Fourier imaging, k-space imaging

BFP of perovskite photonic structures



Zher Ying Ooi



PL spectroscopy is pretty groovy

There are many ways to use optical microscopy and using them in concert enables deeper insights

Interpreting transient data is not always straightforward

Techniques from biology do not always work in materials science

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Eelco K. Tekelenburg
Hong-Hua Fang**

**Paulina Plochocka
Mateusz Dyksik**

**Shuyan Shao
Sampson Adjokatse
Martha Rivera Medina
Matteo Pitaro
Alexander J. Rommens
Machteld E. Kamminga**

**Filippo de Angelis
Daniele Meggiolaro
Luca Gregori**

**Sam Stranks
Beth Tennyson
Kyle Frohna
Alan Baldwin
Barney Lewis
Zher Ying Ooi**



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Thank you for your attention.