Optical spectroscopy of new 2D materials
experimental opportunities at the University of Warsaw

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LaSsO
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SABEL

Double access

Within the frame of the **ISABEL** project, EMFL introduces a novel **dual access procedure** which invites users at an early stage of their research projects and lowers the barrier for access as well.

Within **one experiment proposal**, users will have the possibility to apply both for :

- first-step access to research equipment dedicated to the moderate-field range accessible with superconducting magnets,
- a subsequent second step to the highest possble magnetic fields at the EMFL installations in Grenoble, Nijmegen, Toulouse and Dresden.

For performing experiments in the moderate-field range, thanks to the ISABEL project, EMFL has partnered with

well-equipped and experienced regional facilities distributed over Europe.

Research Laboratories
of the Faculty of Physics, University of Warsaw

Optical spectroscopy in magnetic field

16 T SC magnet for experiments in Faraday configuration,

10 T SC magnet for experiments in Faraday or Voigt configuration,

3T SC two-coil vector-rotate magnet allowing smooth transition from Faraday to Voigt geometry or in-plane rotation of the magnetic field in the Voigt geometry.

Each magnet is equipped with variable-temperature insert (VTI) allowing measurements from room temperature down to pumped helium (about 1.5 K). Persistent switches at SC coils, allow for extended stay at a single field in addition to regular field-sweep measurements

Research Laboratories
of the Faculty of Physics, University of Warsawd

Available techniques:

- Reflectivity and transmission, Raman scattering, Photoluminescence (PL, PLE) with variety laser sources
- Typical signal detection using Si CCD camera (400-1000 nm). InGaAs detector (up to 1700 nm) available upon request.
- Time-resolved PL: Excitation using femtosecond laser near 400 nm, or between 600 and 950 nm (tunable), detection using streak camera (S1 or S20 cathode, temporal resolution down to 3 ps), or detection using APD (quantum efficiency higher than streak camera, temporal resolution down to 50 ps).
- Photon correlations using Si APDs, Ultrafast pump-probe spectroscopy (details upon request)

Successful experiments

THE JOURNAL OF PHYSICAL CHEMISTRY LETTERS
A JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JPCL
Letter

Quantification of Exciton Fine Structure Splitting in a Two-Dimensional Perovskite Compound

Katarzyna Posmyk, Natalia Zawadzka, Mateusz Dyksik, Alessandro Surrente, Duncan K. Maude, Tomasz Kazimierczuk, Adam Babiński, Maciej R. Molas, Watcharaphol Paritmongkol, Mirosław Mączka, William A. Tisdale, Paulina Płochocka,* and Michał Baranowski*

Cite This: *J. Phys. Chem. Lett.* 2022, 13, 4463–4469
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RESEARCH ARTICLE
ADVANCED OPTICAL MATERIALS
www.advopticalmat.de

Exciton Fine Structure in 2D Perovskites: The Out-of-Plane Excitonic State

Katarzyna Posmyk, Mateusz Dyksik, Alessandro Surrente, Duncan K. Maude, Natalia Zawadzka, Adam Babiński, Maciej R. Molas, Watcharaphol Paritmongkol, Mirosław Mączka, William A. Tisdale, Paulina Plochocka, and Michał Baranowski**

PHYSICAL REVIEW LETTERS **129,** 067402 (2022)

Strain-Induced Exciton Hybridization in WS_2 Monolayers Unveiled by Zeeman-Splitting Measurements

Elena Blundo,[1,*] Paulo E. Faria Junior,[2,†] Alessandro Surrente,[1,3] Giorgio Pettinari,[4] A. Prosnikov,[5] Katarzyna Olkowska-Pucko,[6] Klaus Zollner,[2] Tomasz Woźniak,[7] Andrey Chaves,[8,9] nasz Kazimierczuk,[6] Marco Felici,[1] Adam Babiński,[6] Maciej R. Molas,[6] Peter C. M. Christianen,[5] Jaroslav Fabian,[2] and Antonio Polimeni[1,‡]

RESEARCH ARTICLE
ADVANCED OPTICAL MATERIALS
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Spatially Controlled Single Photon Emitters in hBN-Capped WS_2 Domes

Salvatore Cianci, Elena Blundo, Federico Tuzi, Giorgio Pettinari, Katarzyna Olkowska-Pucko, Eirini Parmenopoulou, Djero B. L. Peeters, Antonio Miriametro, Takashi Taniguchi, Kenji Watanabe, Adam Babinski, Maciej R. Molas, Marco Felici, and Antonio Polimeni**

JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
Open Access

pubs.acs.org/JACS
Article

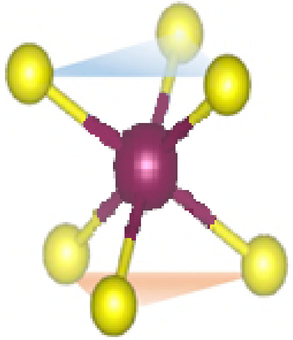
Bright Excitonic Fine Structure in Metal-Halide Perovskites: From Two-Dimensional to Bulk

Katarzyna Posmyk, Natalia Zawadzka, Łucja Kipczak, Mateusz Dyksik, Alessandro Surrente, Duncan K. Maude, Tomasz Kazimierczuk, Adam Babiński, Maciej R. Molas, Wakul Bumrungsan, Chanisara Chooseng, Watcharaphol Paritmongkol, William A. Tisdale, Michał Baranowski,* and Paulina Plochocka*

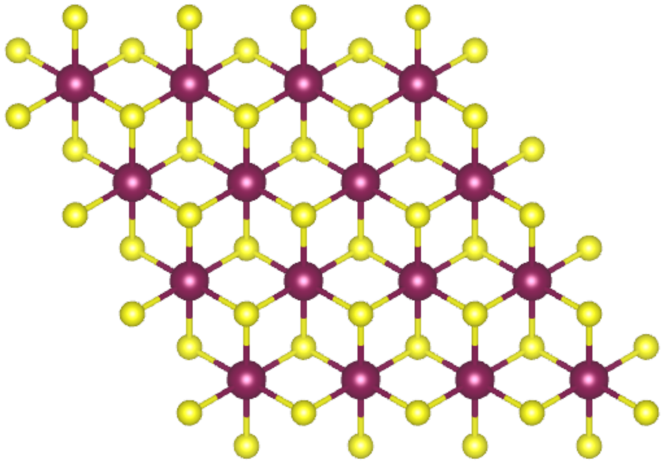
Cite This: *J. Am. Chem. Soc.* 2024, 146, 4687–4694
Read Online

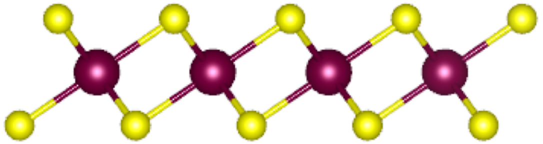
Ready for the challenge, waiting for new opportunities

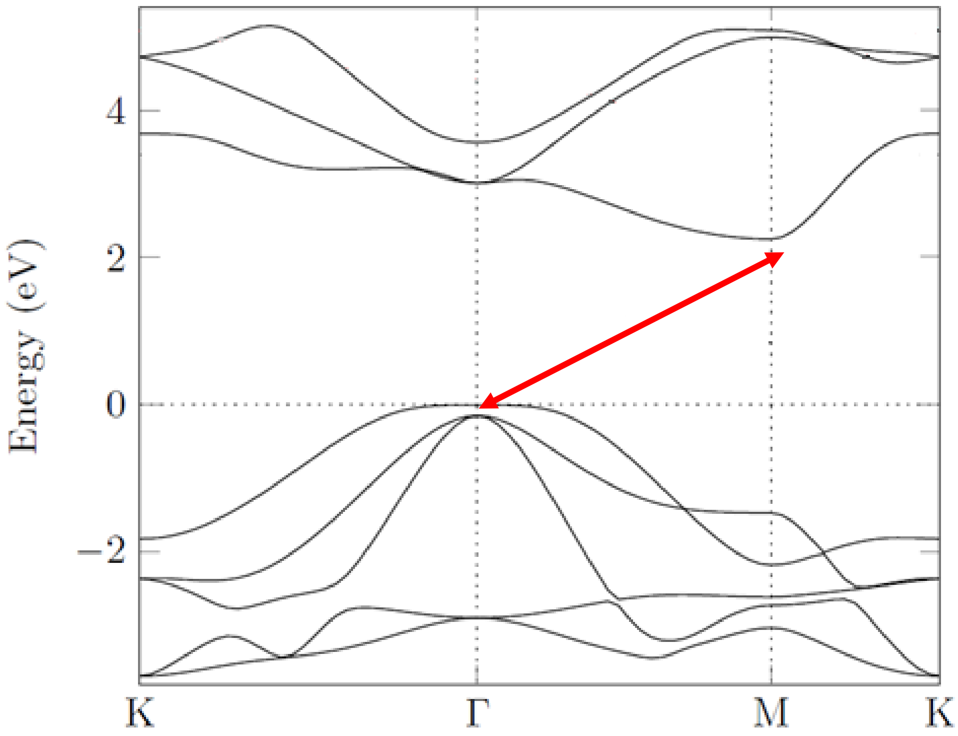
A recent in-house study - hafnium disulphide (HfS_2)



- Semiconductor transition metal dichalcogenide
- Hexagonal crystal lattice
- 1T octahedral configuration
- Promising electrical properties

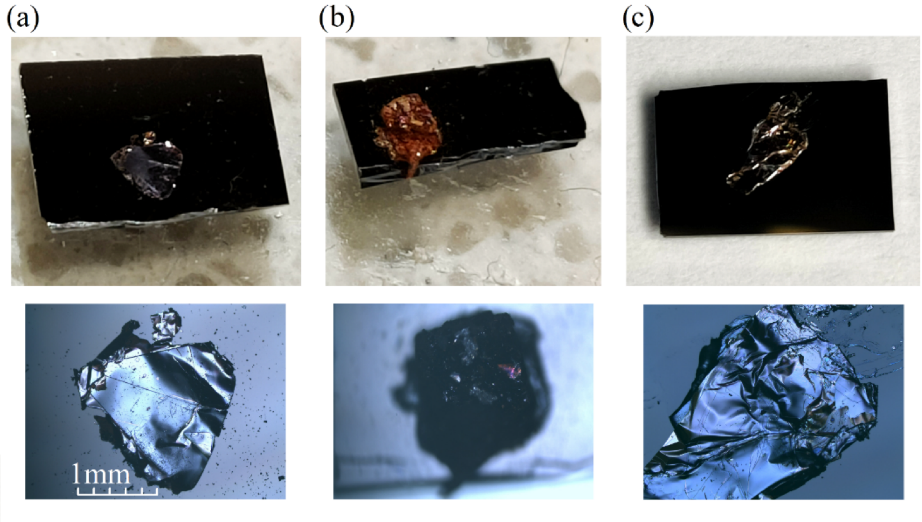




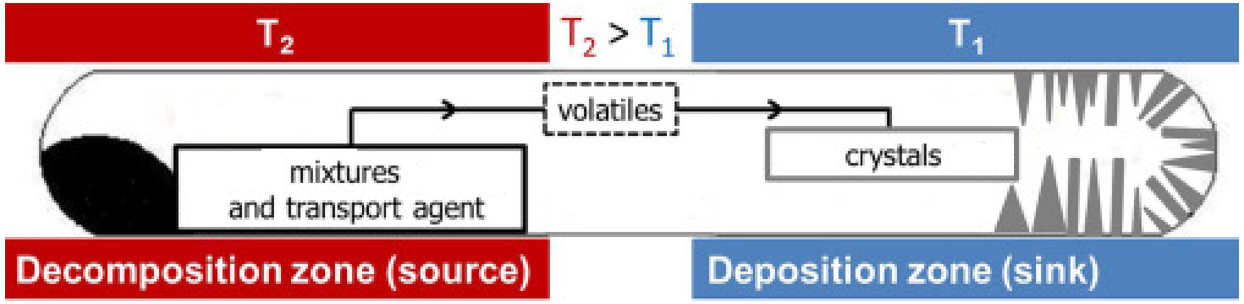


C. Habenicht, et. al., PhysRevB, 98, 155204, (2018)

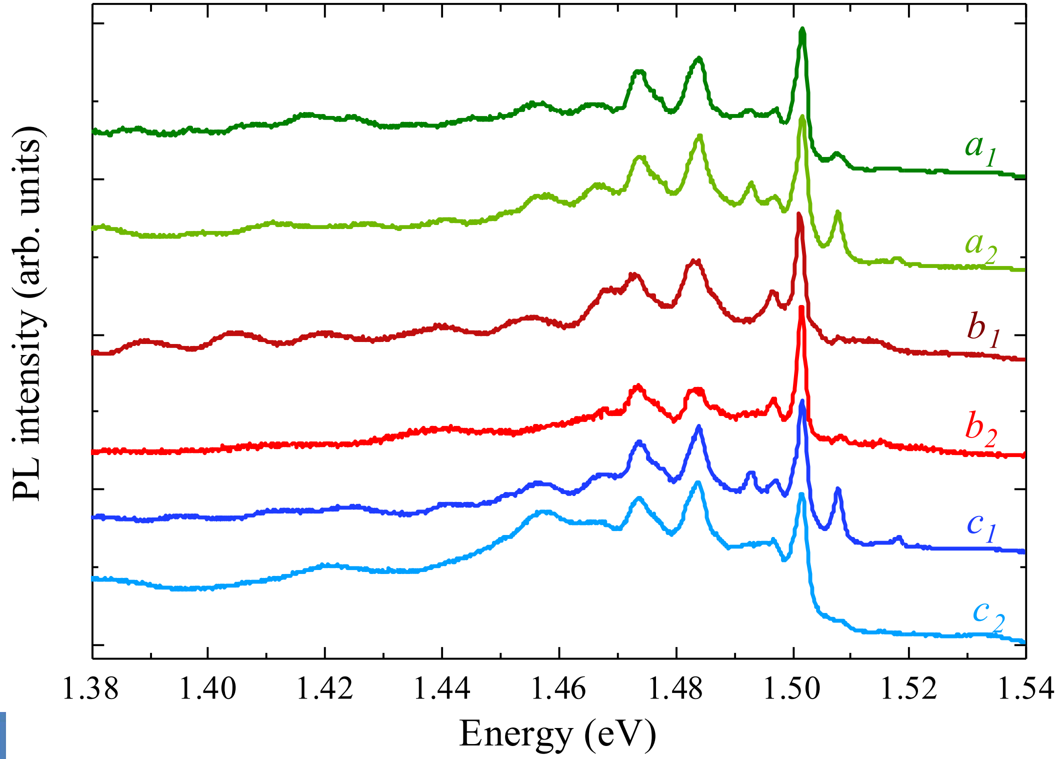
Photoluminescence at 5 K



Crystals from different sources grown by chemical vapour transport method

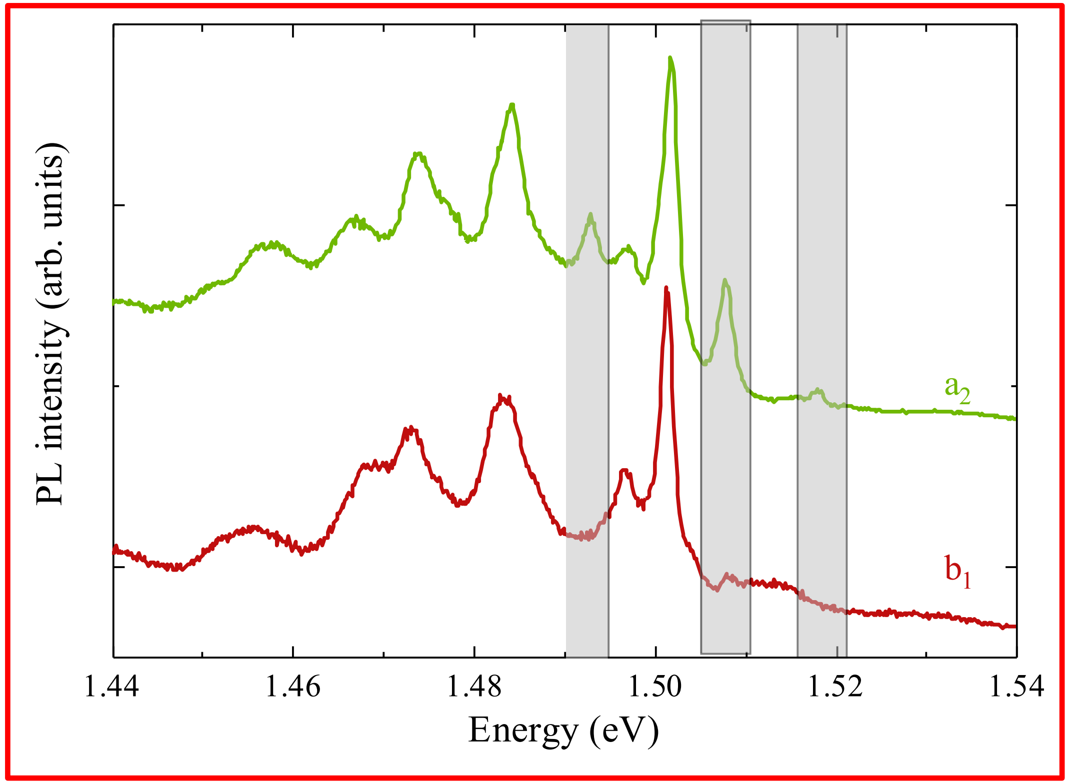


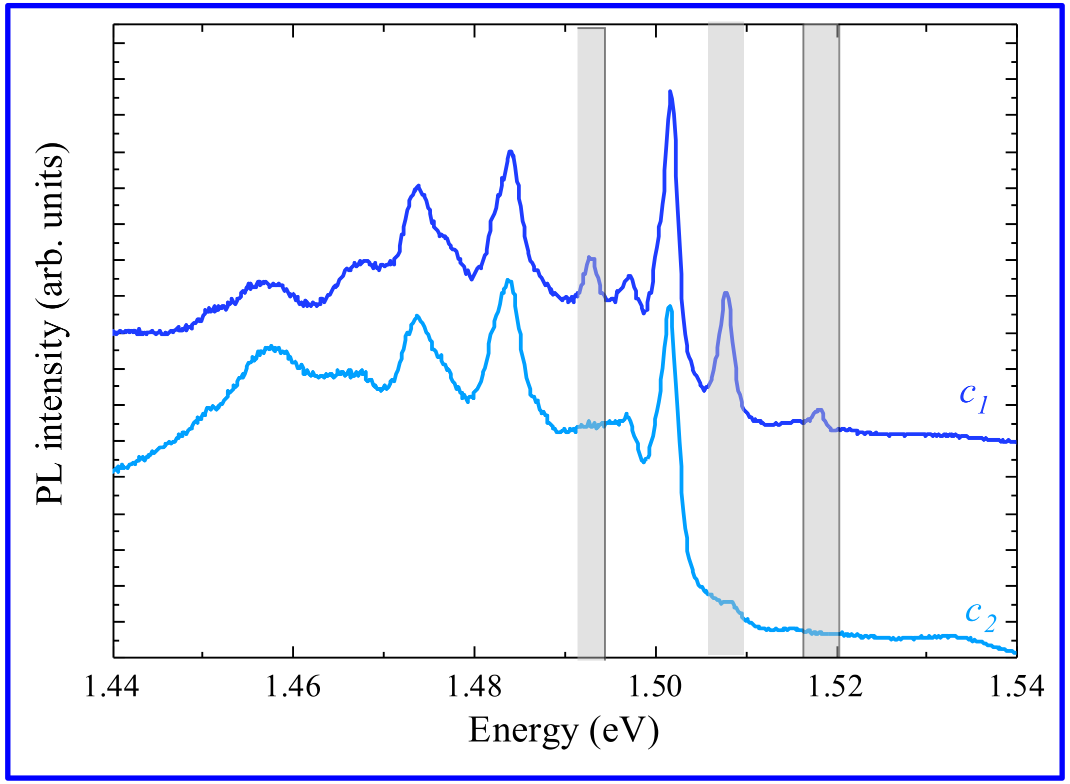
C. Novka, et. al., Journal of Crystal Growth, 459, 81, (2017)



Defect-related low-temperature emission

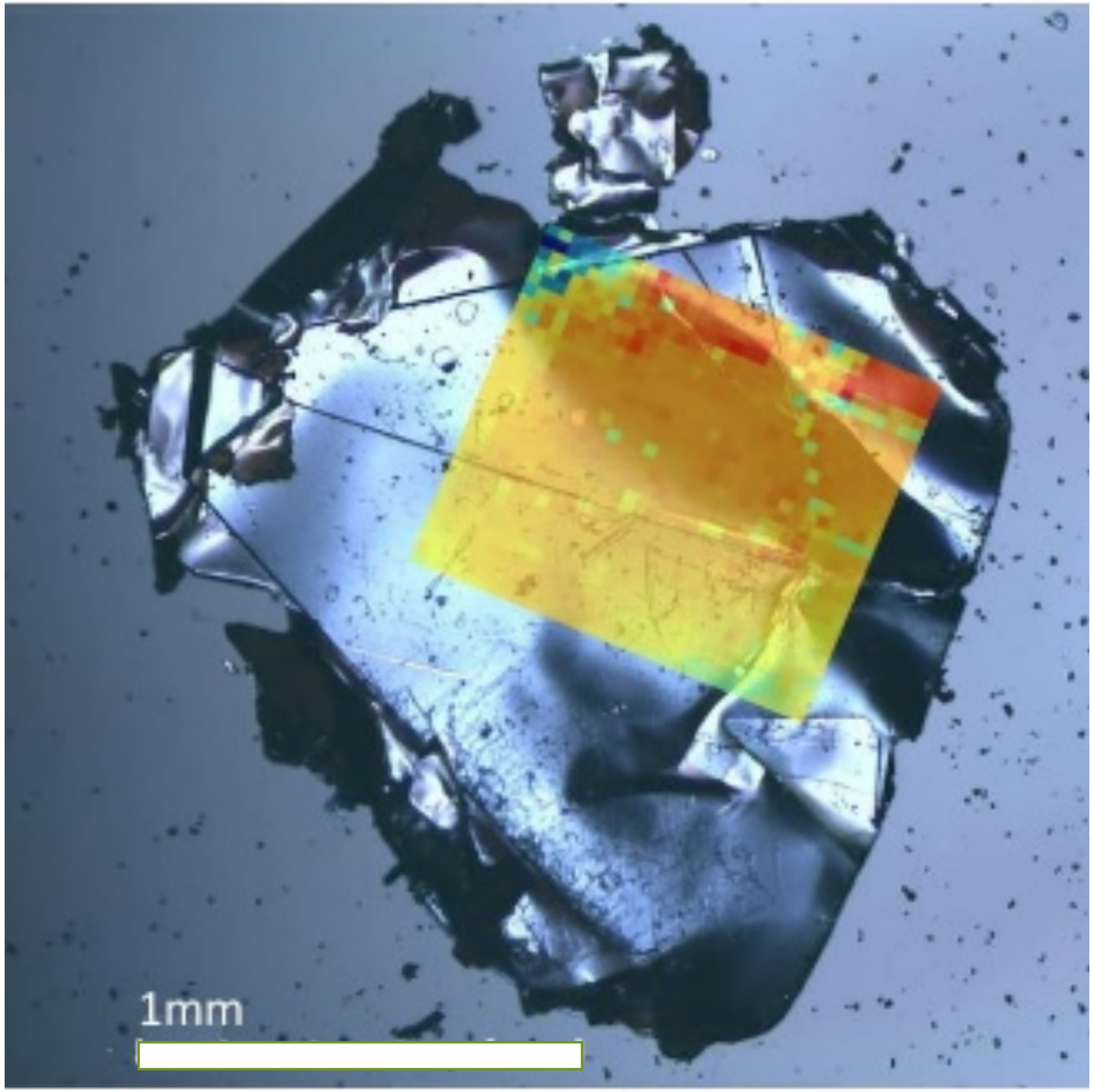
Correlation of the intensity of emission lines





The observed correlation between the intensities of some emission lines in PL from different samples / different spots on the sample

Correlations of the intensity of emission lines



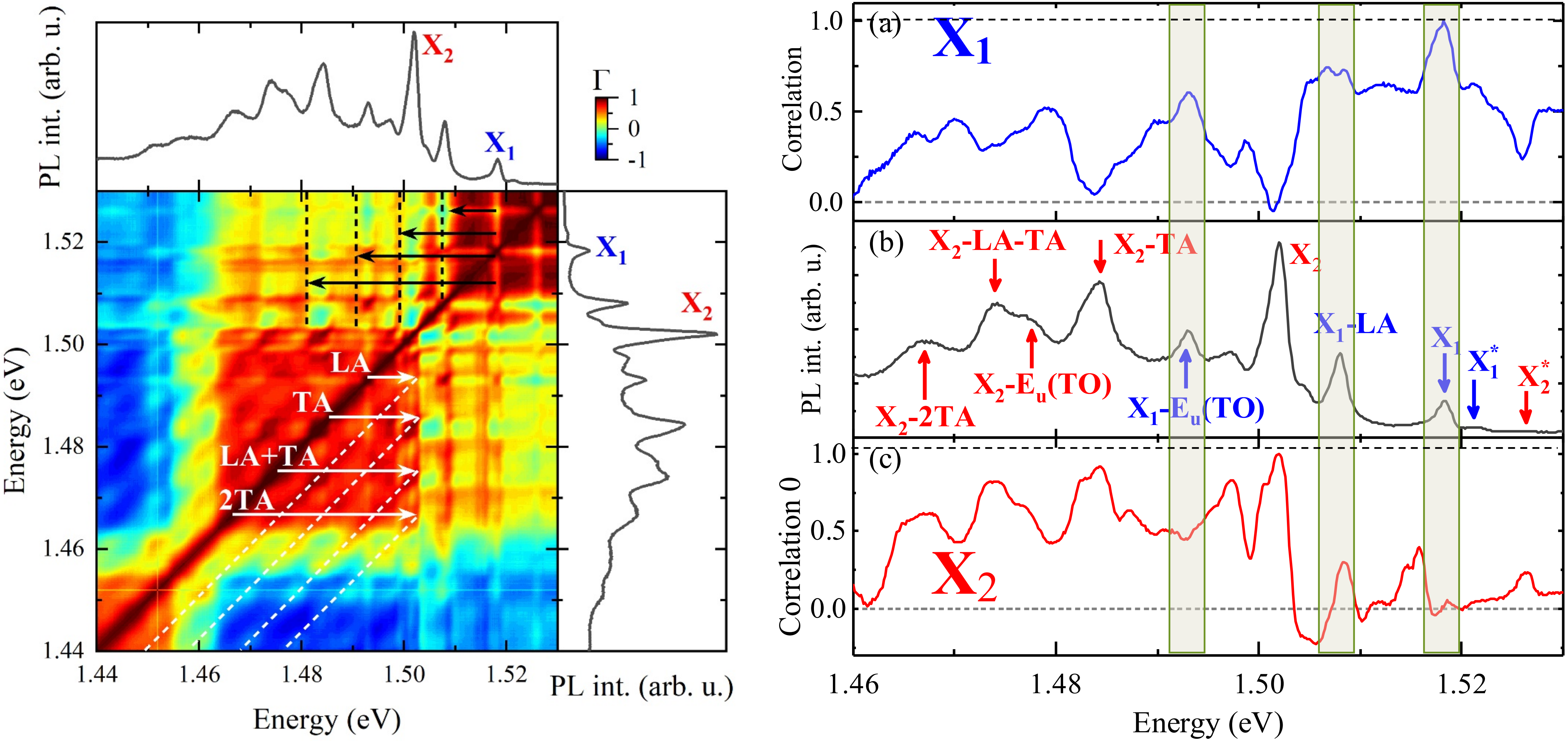
920 spectra collected over the area of the sample

The correlation between intensities at different energies α and β in the PL spectrum can be expressed by the formula:

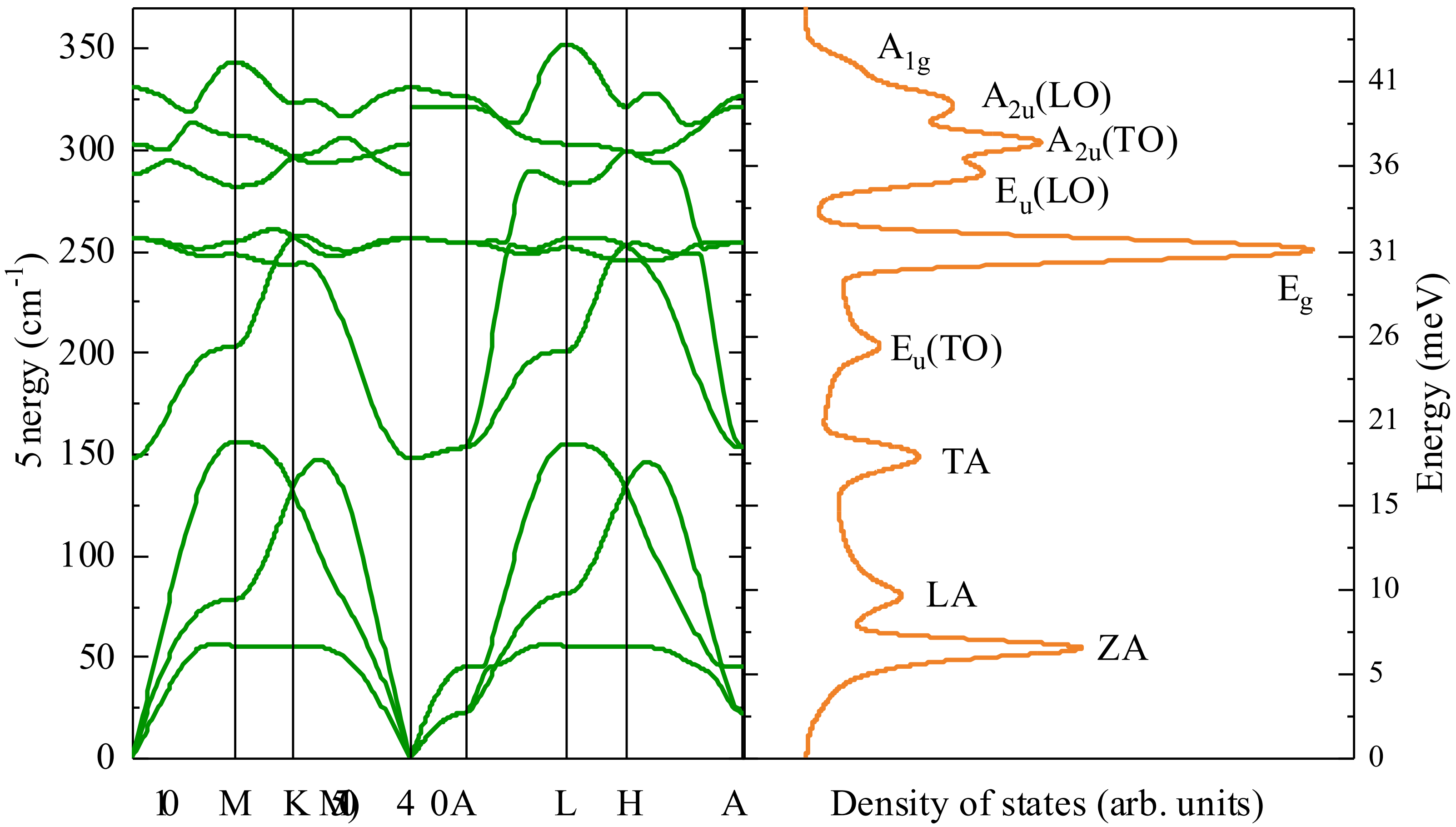
$$\Gamma = \frac{\Sigma_i (I_i^\alpha - \overline{I^\alpha})(I_i^\beta - \overline{I^\beta})}{\sqrt{\Sigma_i (I_i^\alpha - \overline{I^\alpha})^2 \Sigma_i (I_i^\beta - \overline{I^\beta})^2}}$$

B. Piętka, et. al., Phys. Rev B, 87, 035310, (2013)

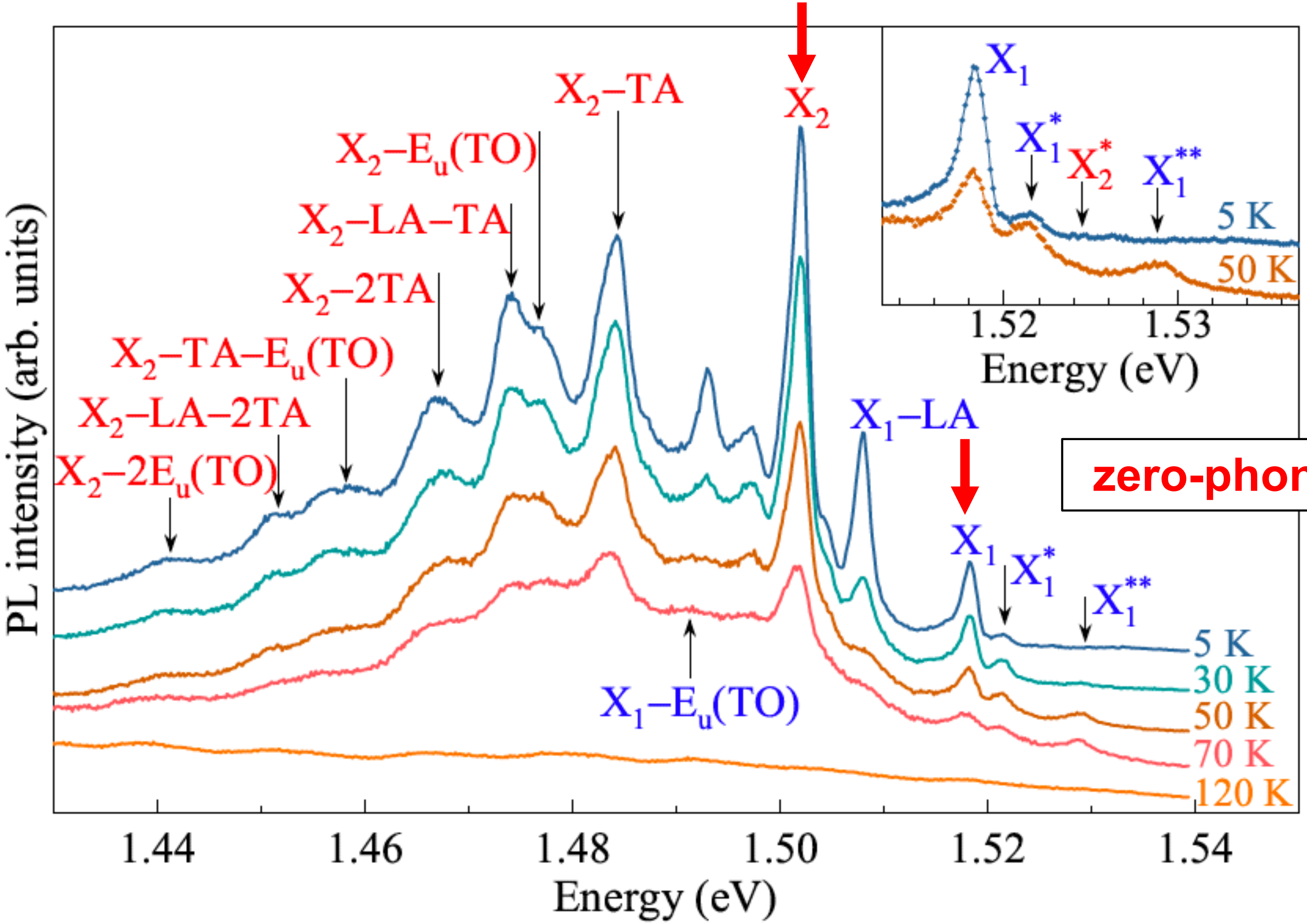
Correlations of the emission lines intensity



Density of phonon states in HfS_2



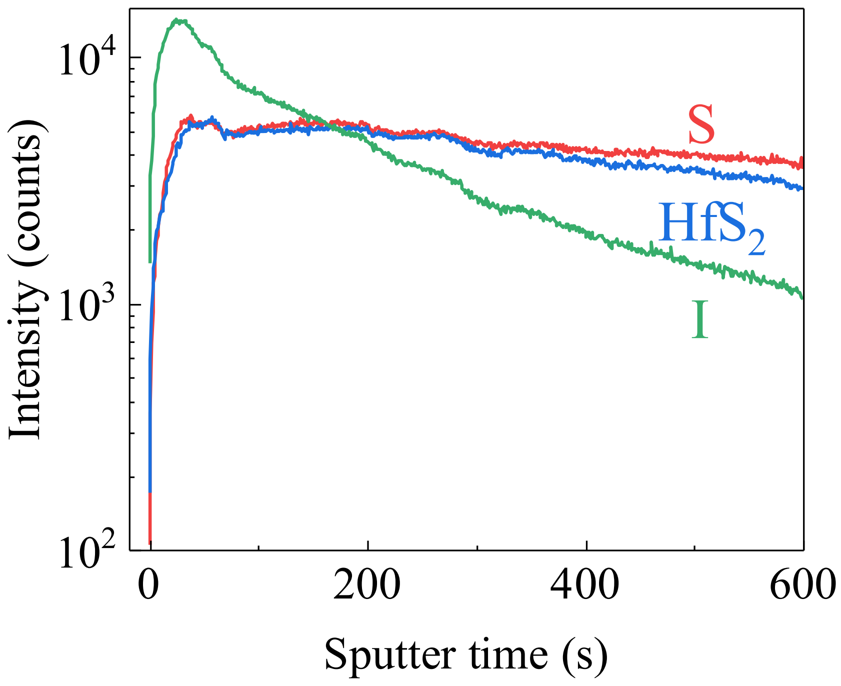
Strong electron-phonon coupling in HfS_2

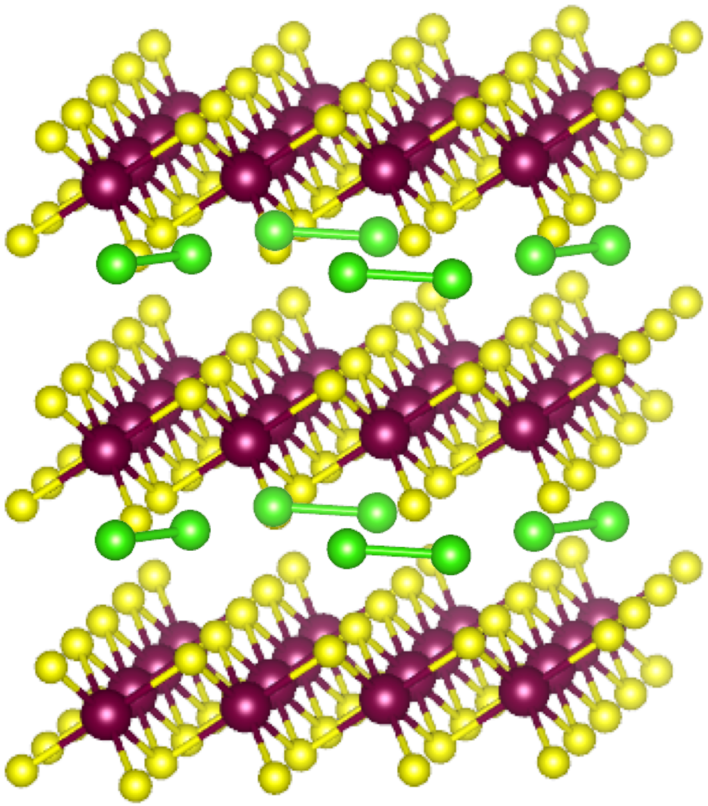


zero-phonon lines

Secondary Ion Mass Spectroscopy (SIMS)

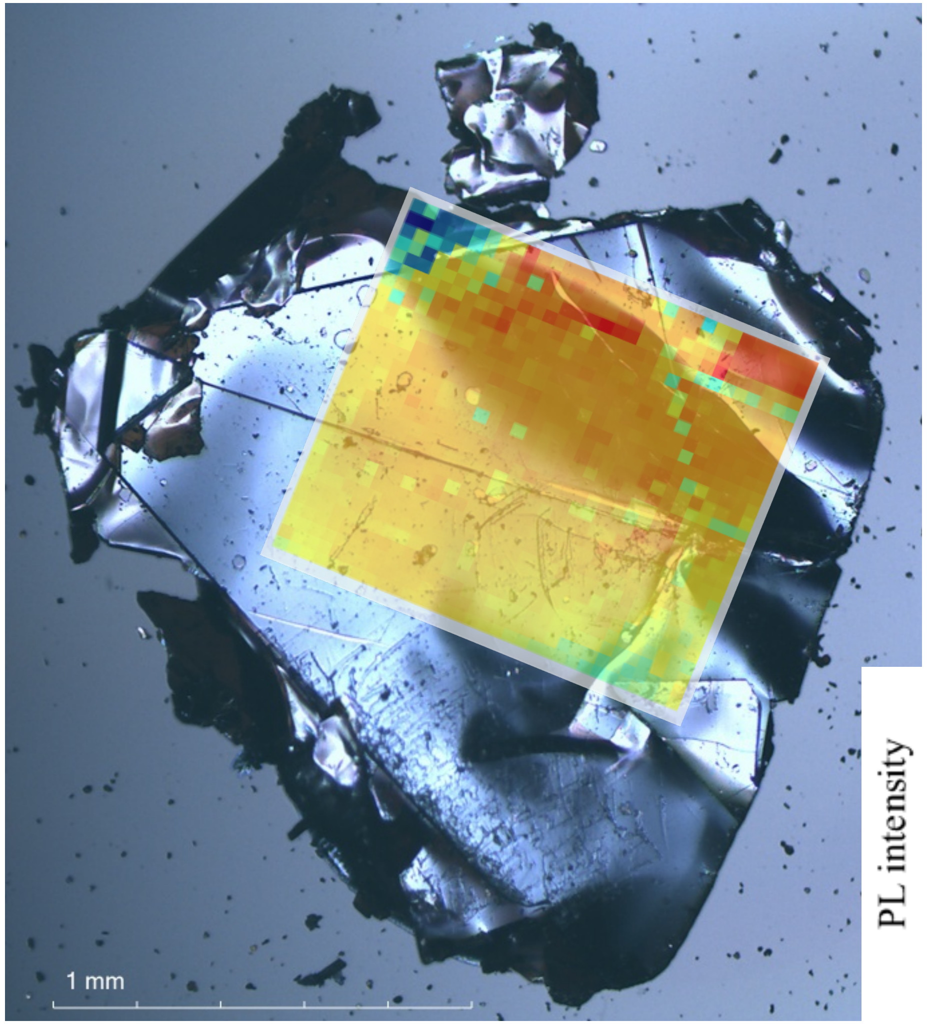
Intercalation of I_2 molecules



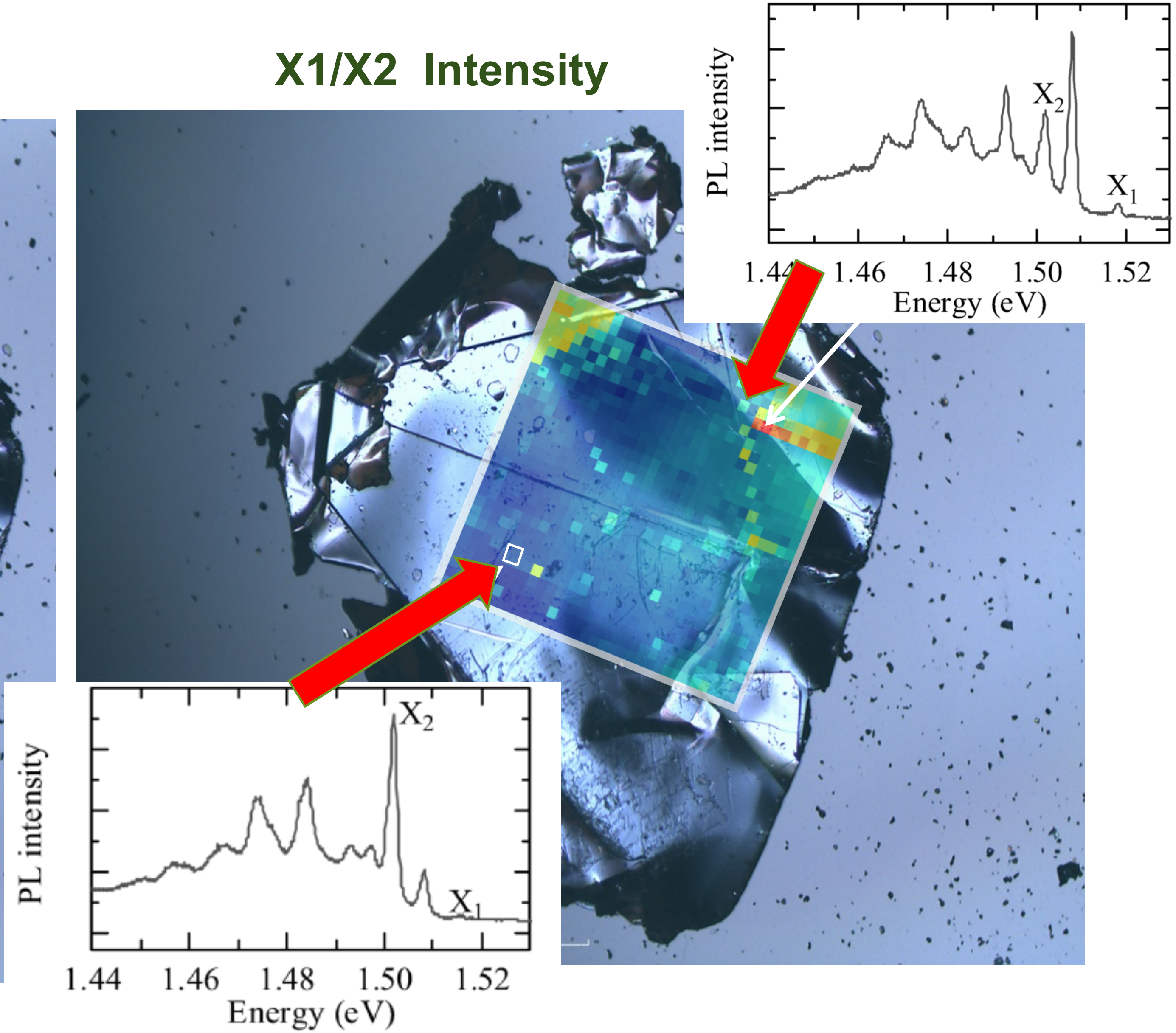


Iodine is the transport agent in CVT process

Integrated intensity



X1/X2 Intensity



Conclusions

- Low-temperature photoluminescence in HfS_2 was observed.
- Correlation analysis of spectra allowed to relate the observed peaks to two families of lines most likely related to a neutral and charged exciton.
- The families comprise zero-phonon features and their phonon replica.
- The emission was related to the presence of the iodine in the van der Waals gaps of material.

for more information see:

N. Zawadzka et al, Appl. Phys. Lett. **122**, 042102 (2023) DOI: 10.1063/5.0126894

Last but not least – do not hesitate to register for

25th International Conference on High Magnetic Fields in Semiconductor Physics
to be held in Warsaw, Poland from 16 to 20 September 2024
http://hmf25.fuw.edu.pl

Early bird registration:
23 June 2024
Final registration:
21 July 2024