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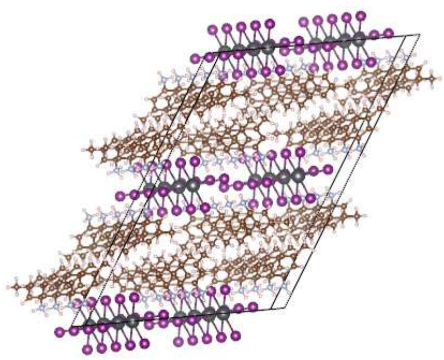
Optical studies of 2D perovskites

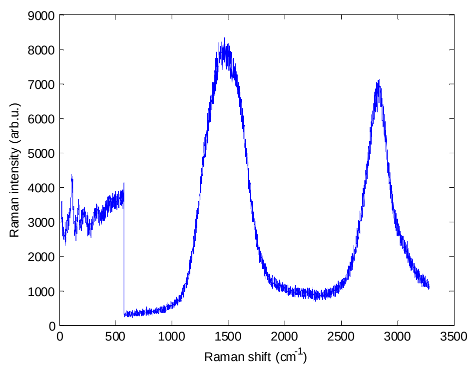
Period	6 months beginning not later than: ☐ January ☒ February ☐ March ☐ April ☐ May ☐ June ☐ July ☒ September 2021
Internship supervisor(s)	name: Pascal Puech, Dr, Adnen Mlayah, Pr e-mail: pascal.puech@cemes.fr, adnen.mlayah@cemes.fr group: M3, NEO, CEMES
Location	CEMES 29 rue Jeanne Marvig 31055 Toulouse - FRANCE
This research master's degree research project could be followed by a PhD	☐ YES ☒ NO

Currently, the high interest for the perovskite family is up to the challenges in terms of light emission and solar cells. Globally understood stability issues and conversion efficiencies exceed 25%, now on par with well-established technologies, such as silicon. Their widespread success is due, in part, to a unique ability to maintain high-quality optoelectronic performance while being readily packaged in thin films. This functionality is what defines them as a whole new class of optoelectronic materials competing with III-V or II-IV semiconductors.

These soft materials are very rich in terms of physics. The very strong electron-phonon coupling can be studied using optical techniques. CEMES is very well equipped in optical spectrometers (Raman, photo-current, luminescence) as well as X-ray diffraction and electron microscopy allowing not only to characterize these materials but also to arrive at an advanced understanding of the phenomena involved.



Exemple of 2D perovskite (VESTA visualization)



Raman spectra at low frequencies (vibration of tetrahedron PbI_4) and at high frequencies (organic spacers)

This internship focuses in particular on 2D perovskites where the planes of tetrahedra (PbI_4) are spaced apart by organic molecules. We will study several effects, namely (1) the stability as a function of temperature and fluence with different excitation energies, (2) the excited state and understand the degradation under strong illumination and also (3) try to extract from the bulk few atomic layers to do tip enhanced Raman spectrometry. Other experiments, depending on the intermediate results, will complete this panel. All of these studies aim to elucidate stability and better understand the underlying physics. At the end of the internship, understanding the degradation processes on 2D perovskites will lead to proposing more stable formulations and to understanding the optimal conditions of operation. This work is part of a research program with the LNCMI, Toulouse.

References:

- Steele, J. A., Puech et al (2019). Role of Electron–Phonon Coupling in the Thermal Evolution of Bulk Rashba-Like Spin-Split Lead Halide Perovskites Exhibiting Dual-Band Photoluminescence. *ACS energy letters*, *4*(9), 2205-2212.
- Yangui, A., Pillet, S., Mlayah et al (2015). Structural phase transition causing anomalous photoluminescence behavior in perovskite (C6H11NH3) 2 [PbI4]. *The Journal of chemical physics*, *143*(22), 224201.

Keywords, areas of expertise	Perosvkite, Raman, Transmittance, Luminescence, Optics, solid state physics
Required skills for the internship	Taste for experiment, computer fluence (data treatment), precise gesture (TERS experiment)