Master dissertation defence

September 15th, 2026. 0.10.6 Seminar

Master in Molecular Nanoscience and Nanotechnology

15:30 Haritz Mentaste Ruiz
Modulating WSe2 photoluminescence through ferroelectric polarisation coupling in a van der Waals heterostructure

16:00 Lucía Martínez Moya
Perovskite/Silicon Tandem Solar Cells with Close-Space Sublimation

16:30 Carlos Martínez Martín
Ti-based MOFs as Biomimetic Artificial Metalloproteases

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Master's thesis in

Nanoscience and Molecular Nanotechnology

Modulating WSe_2 photoluminescence through ferroelectric polarisation coupling in a van der Waals heterostructure

Haritz Mentaste Ruiz

Supervisor:

Dr. Efrén Navarro Moratalla

2025/2026 Academic Year

Abstract

Two-dimensional van der Waals heterostructures provide a versatile platform for investigating interfacial coupling between materials with complementary electronic and optical properties. In this work, we designed and fabricated $CuInP_2S_6$ (CIPS)/WSe_2 heterostructures aimed at enabling the in situ modulation of WSe_2 photoluminescence through ferroelectric polarisation switching in CIPS. Three device generations were developed to address limitations associated with electrical contacting, mechanical stability, thermal transfer, and photoluminescence quenching. The fabrication workflow was progressively optimised, including the incorporation of a copper heat spreader that reduced the polycarbonate transfer temperature from 230 to 180 °C. Monolayer WSe_2 was identified by optical contrast and photoluminescence spectroscopy, and an automated XY mapping routine with pseudo-Voigt fitting was implemented to characterise spatial variations in the emission. The final device exhibited heterogeneous photoluminescence across the WSe_2/CIPS interface and a 26.9% reduction in normalised emission relative to a nearby isolated WSe_2 region. These observations are consistent with interfacial coupling, although the contribution of ferroelectric polarisation could not be isolated in the absence of in situ electrical switching and domain-resolved measurements. The device architecture and analysis workflow developed here provide a basis for future studies of electrically controlled excitonic emission in ferroelectric/semiconductor heterostructures.

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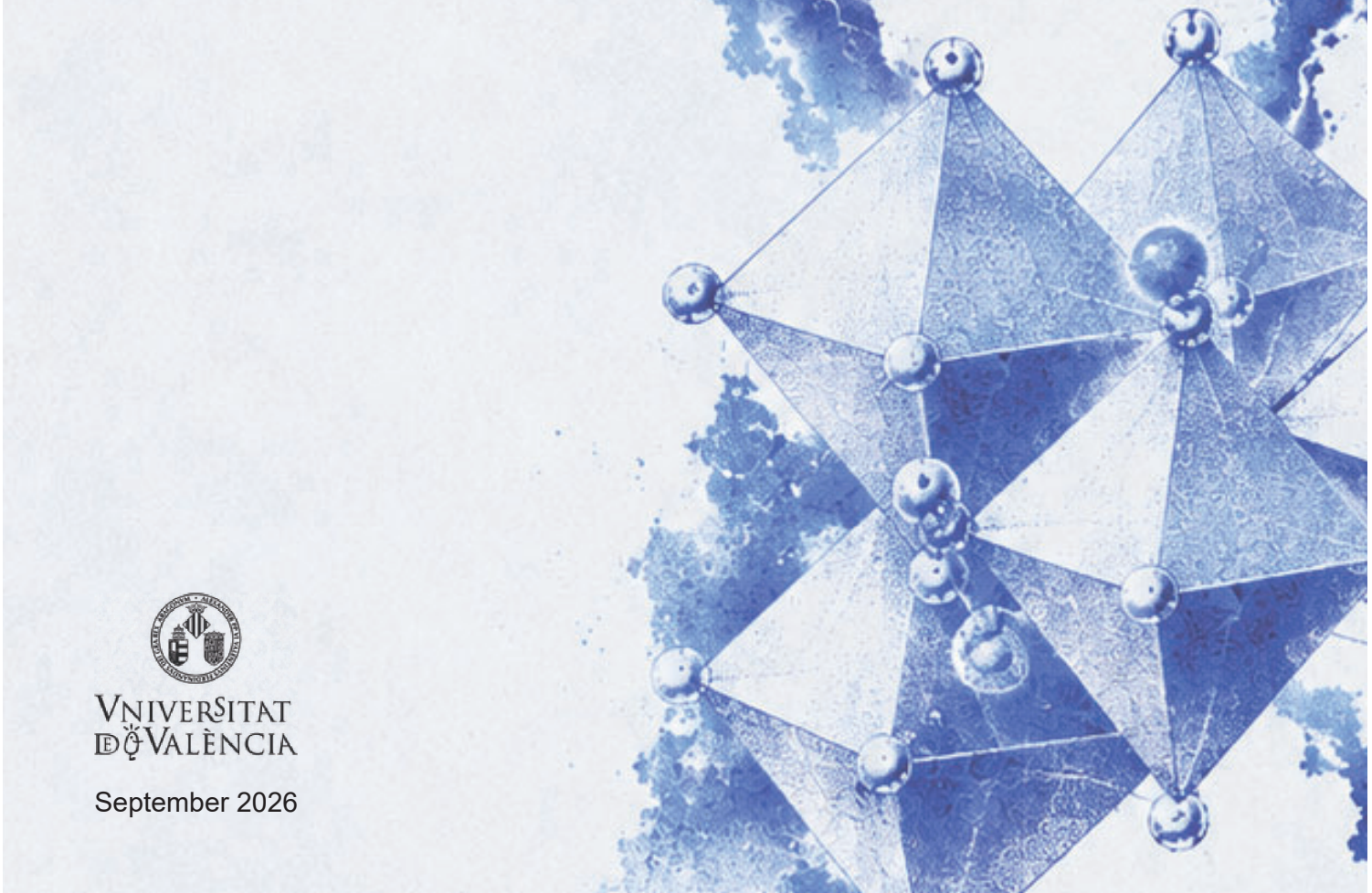
Master in Molecular Nanoscience and Nanotechnology

Perovskite/Silicon Tandem Solar Cells with Close-Space Sublimation

Lucía Martínez Moya

Master's Final Project

Supervisor: Prof. Henk J. Bolink



VNIVERSITAT DE VALÈNCIA

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Abstract

Perovskite/silicon tandem solar cells can exceed the efficiency limit of silicon, but most reported devices rely on solution processing and on flattened wafers. This work uses close-space sublimation (CSS), a vapour-phase route compatible with fully textured industrial silicon, to form the perovskite absorber, and evaluates what such devices deliver and what limits them. The conversion of the co-sublimed PbI_2:CsI scaffold is characterised as a function of conversion time by diffraction and electron microscopy. It is complete within 15 min, and it is described by a one-dimensional moving-front model that accounts for it with one rate constant and one expansion factor. About a third of the scaffold is empty space, by three independent routes, and much of the perovskite formed fits into it, so the absorber follows the pyramids of the wafer instead of burying them. Monolithic two-terminal tandems fabricated on commercial bottom cells from three suppliers reach 23.5 %, with three devices above 23 % from two independent batches. Sub-cell-resolved measurements locate the limit in the current, which is set by the silicon bottom cell and is what keeps these devices from higher efficiencies. The perovskite sub-cell contributes at most 1.13 V, and a higher voltage from it is the next lever.

Resumen

Las células solares en tándem de perovskita y silicio pueden superar el límite de eficiencia del silicio, pero la mayoría de los dispositivos publicados se basan en procesado en disolución y en obleas aplanadas. Este trabajo emplea la sublimación en espacio reducido (CSS), una ruta en fase vapor compatible con silicio industrial completamente texturado, para formar el absorbedor de perovskita, y estudia qué rinden esos dispositivos y qué los limita. La conversión del andamio cosublimado de PbI_2:CsI se caracteriza en función del tiempo de conversión mediante difracción y microscopía electrónica. Se completa en 15 min y se describe con un modelo unidimensional de frente móvil que la describe con una constante de velocidad y un factor de expansión. Cerca de un tercio del andamio es hueco, por tres vías independientes, y buena parte de la perovskita formada cabe en él, de modo que el absorbedor sigue las pirámides de la oblea en vez de enterrarlas. Los tándems monolíticos de dos terminales fabricados sobre células inferiores comerciales de tres proveedores alcanzan el 23.5 %, con tres dispositivos por encima del 23 % procedentes de dos lotes independientes. Las medidas resueltas por subcélula sitúan el límite en la corriente, que fija la célula inferior de silicio y es lo que impide alcanzar mayores eficiencias. La subcélula de perovskita aporta como máximo 1.13 V, y un voltaje mayor por su parte es la siguiente palanca.

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MASTER'S DEGREE IN MOLECULAR NANOSCIENCE AND NANOTECHNOLOGY

Ti-BASED MOFs AS BIOMIMETIC ARTIFICIAL METALLOPROTEASES

Submitted by Carlos Martínez Martín

Supervised by Carlos Martí Gastaldo, PhD and Antonio Pérez Romero, PhD

September 2026

Metal–organic frameworks (MOFs) offer structurally tunable platforms for the development of artificial protease-like systems, yet heterometallic Ti-based frameworks remain comparatively unexplored for protein processing. Here, MUV-101(Fe) and MUV-101(Zn) were investigated using ovalbumin (OVA) as a model protein substrate. Formation of the expected crystalline phases was supported by powder X-ray diffraction. Protein–MOF interactions were monitored by UV–Vis spectroscopy and circular dichroism (CD) under aqueous conditions at 25 and 60 °C and, separately, under blue-light irradiation (440 nm) at room temperature. Selected samples were further examined by SDS-PAGE, and selected gel bands from the thermal-incubation assays were analyzed by LC–MS/MS.

Both materials induced rapid and pronounced alterations in the spectroscopic profile of OVA, including loss of characteristic CD features, consistent with substantial conformational perturbation. Comparable spectroscopic responses were observed with and without irradiation and at both temperatures, indicating that neither photoactivation nor elevated temperature was required for these changes. SDS-PAGE revealed heterogeneous lower-molecular-weight species under selected conditions but did not independently establish MOF-specific proteolysis. LC–MS/MS analysis of selected thermal-incubation samples identified differential non-tryptic peptide boundaries consistent with proteolytic processing associated with both materials. At 25 °C, nine and thirteen cleavage positions were detected in the MUV-101(Fe)- and MUV-101(Zn)-containing samples, respectively, but not in their corresponding controls, whereas interpretation at 60 °C was limited by unequal proteomic coverage.

Overall, the results support proteolytic processing of OVA associated with both MUV-101 frameworks, but do not establish a definitive ranking of their activity, a highly selective cleavage pattern, or an unequivocal Ti–Fe or Ti–Zn bimetallic mechanism. Instead, the absence of a clear secondary-metal-dependent trend is more consistent with a Lewis-acid-mediated mechanism in which the Ti centres may play a predominant role in promoting peptide-bond cleavage. These findings support further investigation of heterometallic Ti-based MOFs as artificial protease-like platforms.