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2D Quantum-Confined Metal Organic Chalcogenides

Inorganic semiconductor quantum wells (QWs) are crucial building blocks in modern optoelectronics. The implementation of QWs allows for the manipulation of light-matter interaction in two-dimensional (2D) systems, paving the way for efficient and powerful lasers, light-emitting diodes, and photodetectors.

The development of hybrid semiconductor quantum wells (HQWs), which are nanostructures where organic molecules provide 2D confinement to charge carriers in inorganic layers, can bring radical improvements to optoelectronics. This includes low-cost fabrication, lower environmental impact, device substrate flexibility, and a broader exploitable range of the electromagnetic field. 2D metal halide perovskites (2D-MHPs) are a well-known example of such a material concept. Despite being known for a long time, 2D-MHPs only recently gained attention due to the incredible performance of 3D-MHP-based solar cells. HQWs are quickly finding diverse applications, from visible to UV, X-ray photodetectors to LEDs and solar cells.

In this talk, I will expand the framework of hybrid semiconductor quantum wells to layered metal-organic chalcogenides (MOCs), introducing an underexplored material platform for optoelectronics. I will present our research on photocurrent response in air-stable MOCs prototype $[AgSePh]_\infty$, suggesting possible applications as near-UV and X-ray low-cost photodetectors. Our recent works demonstrated that the $[AgSePh]_\infty$ photophysics is dominated by two-dimensional, anisotropic, and tightly bound (>380 meV) excitons. Finally, I will discuss the exciton dynamics resolved by pump-probe spectroscopy, identifying intrinsic exciton self-trapping, and anharmonic exciton-phonon coupling, two important phenomena impacting the whole class of low-dimensional hybrids.

About the Speaker

Lorenzo Maserati holds a Bachelor (2007) and a Master (2009) degrees in Physics Engineering from Politecnico di Milano (Italy). He did his Master thesis on graphene for STM applications in the Physics Department of UC Berkeley (USA). He obtained his PhD in Nanoscience (2014) from the University of Genoa (Italy) with a thesis on "Colloidal nanocrystal films for optoelectronic applications", working in the Nanochemistry Department of IIT with L. Manna. In 2015 he moved as a Postdoc to the Organic and Macromolecular Facility of the Molecular Foundry (Lawrence Berkeley National Lab, USA) where he developed hybrid materials (MOF) for CO_2 capture and microporous polymers (PIM) for flow batteries. In 2017 he joined the Nanofabrication Facility at the Molecular Foundry where he worked on the ultrafast spectroscopy of nanomaterials and strongly confined systems. From 2018 to 2021 he was a Researcher at CNST in Milan where he developed new metal-organic chalcogenides hybrid quantum wells for a variety of optoelectronic applications. From 2022 to 2023 he was Junior Assistant Professor in the Department of Physics and Astronomy at the University of Bologna carrying on his research on the excitonic properties of low-dimensional hybrid materials and he developed a photoelectrical-based ion spectroscopy for metal halide perovskites. He is now Senior Researcher at LEAP, a Politecnico di Milano spin-off research center working on sustainable energy production and carbon capture. He is recipient of the

Nanoinnovation’s Got Talent award (Bracco Foundation, 2016) and of the Seal of Excellence (Marie Skłodowska-Curie Actions, 2017). In 2022 he was awarded the ESA Discovery Programme Grant by the European Space Agency for developing lightweight hybrid perovskites X-ray detectors.