Light-Matter Interaction in Metal-Organic Chalcogenides Quantum Wells

Inorganic semiconductor quantum wells (QWs) are key building blocks in modern optoelectronics. QWs implementation allows for the manipulation of light-matter interaction in two-dimensional (2D) systems, paving the way to 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, from low-cost fabrication, to lower environmental impact, device substrate flexibility, and to a wider exploitable range of the electromagnetic field. HQWs. 2D metal halide perovskites (2D-MHPs) are a well-known example of such material concept. Despite being known since the 60s, 2D-MHPs only recently made the headlines thanks to the incredible performance of 3D-MHP-based solar cells. HQWs are quickly finding diverse applications: from visible to UV, X- and Γ-ray photodetectors to LED and solar cells.

In this talk, I will expand the framework of hybrid semiconductor quantum wells to layered metal-organic chalcogenides (MOCs), introducing an unexplored 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 photodetector. 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 individuating intrinsic exciton self-trapping, an important phenomenon impacting the whole class of low-dimensional hybrids.

Speaker's Resume

Lorenzo Maserati holds a Bachelor's (2007) and a Master's (2009) degrees in Physics Engineering from Politecnico di Milano. He developed his master's thesis on graphene for STM applications in the Physics Department of UC Berkeley (USA) under the supervision of Prof. M. Crommie. He obtained his PhD in Nanoscience (2014) from the Università degli Studi di Genova with a thesis on "Colloidal nanocrystal films for optoelectronic applications", working in the Nanochemistry Department of IIT under the supervision of Prof. L. Manna. In 2015, he joined as a Postdoc the Helms group, in the Organic and Macromolecular Facility of the Molecular Foundry (Lawrence Berkeley National Lab, USA) where he developed hybrid materials (MOFs) for CO_2 capture and microporous polymers (PIMs) for flow batteries. In 2017, he started working at the Nanofabrication Facility at the Molecular Foundry with Dr. A. Schwartzberg on the ultrafast spectroscopy of nanomaterials and strongly confined systems. From 2018 to 2021, he was an IIT Researcher at CNST in Milan in the printed and molecular electronic group, where he developed metal-organic chalcogenides-based optoelectronic devices for a variety of applications. Since 2022, he is a RTDa in the Physics and Astronomy Department of Università di Bologna. He is the recipient of the Nanoinnovation's Got Talent award (Bracco Foundation, 2016) and of the Seal of Excellence (Marie Skłodowska-Curie Actions, 2017 and 2018).