MD/8 "Materiali nanostrutturati per proprietà funzionali"
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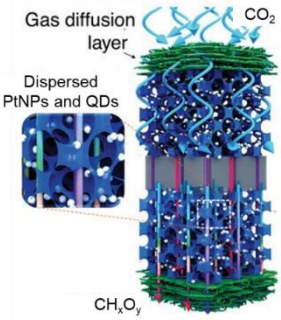
The overall aim of this project is to apply the concept of **architected functional materials** to demonstrate performance enhancement in **photocatalytic systems for CO_2 reduction** ("artificial photosynthesis").

The PhD candidate will work in an multidisciplinary environment on the identification, design, fabrication, and testing of **architected nanostructures**, with the aim of engineering specific functional material properties - most notably, the ability of promoting catalytic activity with a special focus on the **photoreduction of CO_2**. By merging knowledge about **semiconductor quantum dots** and the emerging field of **catalytic nanoarchitectonics**, the PhD candidate will learn and use a broad variety of fabrication techniques (including the colloidal synthesis of **complex hetero-nanostructures** such as multishell and shape-engineered quantum dots, templating, **printing**, and **self-assembly** of nanostructures. Also, s/he will learn a range of standard and advanced material characterization techniques, including electron microscopy, advanced spectroscopies, measurement of the photocatalytic activity.



Architected Materials (AMs) are cellular and/or multiphase systems where the distribution of the material phases is finely controlled and optimized for obtaining specific properties or functions. Particularly interesting are **hierarchical AMs**, where the morphological control of the material distribution occurs at multiple scales (typically nano- micro- and millimeter scale), and the overall dimensions of the component are macroscopic.[1] This structural morphology is known to lead to tailorable, exceptional properties. However, while the **beneficial role of hierarchy in catalytic structures is broadly recognized**[2,3], a systematic understanding of its role and benefitting mechanisms is still lacking.

Therefore, the PhD student will **synthesize and characterize a model Functional Hierarchically Architected Material consisting of a catalytically active nanostructured template, a metal co-catalyzer, and a variety of quantum dot structures,** and then **design, fabricate and test a device for CO_2 photoreduction**. The student will systematically optimize each fabrication step, explore alternative routes – while keeping scalability in mind – and devise the appropriate characterization and testing plans. The twofold aim is to improve **CO_2 photoreduction** (an important stepping stone to meet the urgent societal challenges of **clean energy** and **climate action**) as well as to shed some light on the role of hierarchy on the catalytic performance.

Specific objectives are the demonstration of the **feasibility of a fabrication process for *sizeable* quantities** of a hierarchically architected functional material, demonstration of a **measurable *architecture-driven* improvement of CO_2 photoreduction**, and the **determination of the specific role of hierarchy and architecture on the on CO_2 photoreduction**.

Ideal candidates should hold a MS or equivalent in materials science and/or engineering, chemistry, physics. However, all suitable profiles will be considered.

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[1] Valdevit L et al., J. Am. Ceram. Soc. 94, 15–34 (2011)
[2] Vu N et al., Adv. Funct. Mater. 29, 1901825 (2019)
[3] Yan Y et al., Nat. Energy 2, 17052 (2017)