Consiglio Nazionale delle Ricerche

Istituto di **Chimica** e della **Materia Condensata** e di **Tecnologie** per l'**Energia**

Advancing the Hydrogen Economy: Materials and Technologies for Production, Storage, and Distribution

Climate change poses an urgent challenge that calls for the rapid deployment of sustainable energy technologies. Hydrogen is increasingly recognized as a key enabler for decarbonizing hard-to-abate sectors, including industry, transportation, and power generation. However, large-scale adoption of hydrogen requires overcoming critical challenges related to its production, storage, and safe distribution. In our research group, three ongoing projects address these issues from complementary perspectives. The HEADSTONE project focuses on the design, synthesis, and testing of lightweight High Entropy Alloys (HEAs) for solid-state hydrogen storage, leveraging their ability to form interstitial metal hydrides with high hydrogen-to-metal ratios. The HOOPLA project investigates the resistance of pipeline and storage vessel materials to hydrogen embrittlement and degradation, with particular emphasis on how processing history and surface treatments influence mechanical reliability. In parallel, a PhD thesis, conducted within the framework of the PON "Doctorates on Green Thematics" program and successfully defended in May 2025, developed cost-effective Raney-Nickel electrocatalytic coatings, produced by atmospheric plasma spray (APS), to be used in alkaline water electrolyzers for green hydrogen production.

***Giulia Poppi**, Ph.D., research fellow at Department of Engineering "Enzo Ferrari", UNIMORE*

Coatings via Magnetron Sputtering Technology for Hydrogen-related Applications

In recent years, the development of effective and durable systems for hydrogen production, storage and transport has been one of the hot topics at the CNR-ICMATE institute. Currently, my research group is involved in:

1. HEADSTONE project → It is focused on the synthesis of High Entropy Alloys (HEAs) for solid-state reversible H_2 storage. In particular, a few microns thick MgAlVCrNi coatings were deposited using a novel approach which combines Glancing Angle Deposition and PVD Magnetron Sputtering technology (GLAD-MS). GLAD allows growing porous films with nanostructured columnar architectures (isolated slanted columns, vertical pillars, zigzag or helicoidal structures), where H_2 should easily flow through the gaps and be absorbed. The geometric configuration developed for GLAD-MS depositions will be described in detail together with produced coatings morphologies and crystal structures.

2. PNRR - "Ricerca e sviluppo sull'idrogeno", Coatings for pipelines for hydrogen transport → Concerning the transport of H_2, atoms can easily diffuse into the metallic matrix of the infrastructure (tanks and pipes consisting of steel, Al or Mg alloys, Ti, etc.), and cause its embrittlement (Hydrogen Embrittlement, HE). HE can be mitigated by blocking/limiting the entry of hydrogen into the metallic material: my research team is working on the deposition of ceramic hydrogen barrier layers (Hydrogen Permeation Barrier, HPB) via PVD-MS. The starting base material was Ti-Al-N, prepared using both DC and High Power Impulse MS configurations. All films were thoroughly characterized and exposed to H_2 atmosphere to test their stability.

Angelica Fasan, research fellow at ICMATE-CNR (Padova), MSc in Industrial Chemistry at the University of Padova

Webinar "MATERIALS MATTER!"
Giulia Poppi, UNIMORE Modena
Angelica Fasan, ICMATE Padova

29/10/2025 3.00-4.00 pm

Participation LINK