THE UNIVERSITY OF SYDNEY

Net Zero Initiative

Alloys for hydrogen economy

Our vision and mission

Clean, cheap, storable hydrogen fuel, produced without emissions and leaving only water when burned, is poised to become a reality in near future. However, a remaining critical problem is hydrogen embrittlement, a phenomenon that can cause sudden, catastrophic failure of stressed metal components exposed to hydrogen. Our research aims to develop the mechanistic understanding of the hydrogen embrittlement process and identify material technology solutions that will enable safe hydrogen pipeline transmission and storage at scale.

Our approach

At the University of Sydney, we have a wide range of advanced tools dedicated to the investigation of how hydrogen behaves in metallic materials, including how it initiates failures at small scales. In particular, we have cryogenic atom probe tomography, a cutting-edge technology that allows ultra high-resolution hydrogen mapping in materials. This allows us to determine which individual microstructural features are responsible for hydrogen embrittlement and will guide the design of durable materials that resist hydrogen embrittlement.

Our research

A key Enabling Research Theme of the Net Zero Initiative (NZI) is 'Emissions Avoidance through Zero Emissions Energy', which is dedicated to facilitating the rise of renewable energy technologies. As part of this, we are investigating technological hurdles to the widespread use of hydrogen fuel. Under the pillar 'Alloys for the Hydrogen Economy', our researchers are examining metal and alloy performance in the presence of hydrogen and developing the solutions for their safe use in hydrogen-rich service environments. Our studies involve in-depth exploration of phenomena that affect metallic materials in hydrogen, including:

- How hydrogen is absorbed by an alloy;
- How hydrogen can be captured within alloy structures, reducing its detrimental effects; and
- What fundamental, scientific mechanisms and stages cause embrittlement and failure.

Our research is leading to new physics-informed materials selection, better component lifetime predictions, and new alloys that increase the efficiency of hydrogen transmission and storage. These outcomes will facilitate the transition to a hydrogen economy.

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Meet our research experts

We have an expert group specialising in metallurgy and materials characterisation. Experts include:

School of Aerospace, Mechanical and Mechatronic Engineering

Dr Yi-Sheng (Eason) Chen: Specialises in Hydrogen Embrittlement and Hydrogen Microscopy.

Professor Julie Cairney: Specialises in Microscopy and Metallurgy.

Professor Xiaozhou Liao: Specialises in Microscopy and Materials Characterisation.

Professor Simon Ringer: Specialises in Microscopy and Metallurgy.

School of Civil Engineering

Professor Anna Paradowska: Specialises in Macroscope Characterisation of Materials

Professor Gwénaëlle Proust: Specialises in Physical Metallurgy.

Professor Luming Shen: Specialises in Computational Materials Science.

We have developed a unique suite of research facilities, especially for imaging the hydrogen atoms in materials, which allows us to extract the most important information relating to the origin of embrittlement.

Our expertise and capabilities have received significant interest and support from industry as they provide an opportunity to renovate existing gas pipelines with new hydrogen-compatible materials.

We can work with you to:

- Establish collaborations with leading academic and industry experts to address business challenges;
- Ensure the next generation of graduates have skills relevant to your business;
- Embed a top performing student to take on industry-specific research projects;
- Develop and integrate technology into your business operations;
- Upskill technicians and executives through micro credentials and short courses;
- Test and prototype products using state of the art facilities; and
- Undertake short, medium and long-term research projects with R&D Tax Incentives.

Ongoing projects

Embrittlement-tolerant alloys for safe hydrogen transmission and storage: Key industry partners are CITIC Metal, POSCO, Microscopy Solutions, Future Fuels CRC, CSIRO and ANSTO. Funding source: Australian Research Council (ARC) Linkage.

Mitigating hydrogen embrittlement in high-strength steels: Key industry partners are CITIC Metal and Baosteel. Funding source: ARC Linkage.

Strategic Approach against Hydrogen Embrittlement in Ultra-High Strength Steels: Key partners are CAMECA and Microscopy Solutions. Funding source: The University of Sydney Fellowship.

Green steels for hydrogen infrastructure: Key partner is Giflo Steels Australia.

Advanced welding for hydrogen pipes: Key partner is Trigonomics.

Contact us

For further information or to discuss in greater detail, please contact:

Net Zero Initiative

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