PREPARING FOR THE HYDROGEN ECONOMY

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Hydrogen has been dubbed the fuel of the future. However, transporting and storing it is difficult because it causes steel to become brittle and fail. In a world first, Sydney researchers have found a way to prevent this embrittlement.

SMALL SAMPLE

BIG IMPACT

Top image: Prof. Julie Cairney operating an atom probe. Bottom image: visualisation of atom probe data showing the hydrogen atoms (white) collecting at dislocations (red).

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$10 billion

The predicted annual value of Australian hydrogen exports by 2040

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CHALLENGE

Hydrogen has been dubbed the fuel of the future. It is a green fuel that can be produced using renewable power and as it is used, only produces water. Hydrogen also provides the unique benefit of being transportable and can be used to store, transport and deliver energy produced form other sources.

Steel is a cheap and hard metal that is ideal for storing and transporting gasses, such as hydrogen, under pressure. However, hydrogen poses a unique challenge. The more hydrogen that permeates the steel, the more brittle it becomes. This process is called hydrogen embrittlement.

Because of it's size it is experimentally challenging to measure the precise location of the atoms in the steel, making it difficult to understand the mechanics behind hydrogen embrittlement. Hydrogen embrittlement can lead to catastrophic failures, making it a critical limitation in moving towards a greener, hydrogen-fuelled future, where steel tanks and pipelines are essential components.

RESEARCH

In a world first, Dr Yi-Sheng Chen and Prof. Julie Cairney, working in partnership with CITIC Metals, have used Microscopy Australia's state-of-the-art cryogenic atom probe at the University of Sydney to directly observe hydrogen in steels.

Although non-microscopic techniques can, and have, identified hydrogen accumulation in metals, they do not allow researchers to work out exactly where the hydrogen atoms go and what kind of features they associate with. From their experiments, the researchers found that hydrogen accumulates at microstructures called dislocations, and at the boundaries between individual crystals. This accumulation causes structural changes that weaken the steel.

The researchers also found the first direct evidence that introducing clusters of niobium carbide into the steel prevents hydrogen from moving through it easily. This trapping effect stops hydrogen from gathering at dislocations and crystal boundaries, preventing embrittlement. These carbides could be key to the informed design of new, embrittlement-resistant steels that could help smooth the way towards a hydrogen-fuelled future.

IMPACT

This research provides a solution to one of the most enduring challenges of using hydrogen as a fuel – it's storage and transportation – which is critical to the development, and scaling up, of the hydrogen industry. CITIC metals, who produce niobium, hope this will encourage steel makers to incorporate niobium carbide into steels for hydrogen related applications.

Australia's National Hydrogen Strategy sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians. The strategy aims to position the Australian hydrogen industry as a major player by 2030. This research will be critical to making this happen, enabling the mass transport of hydrogen.

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