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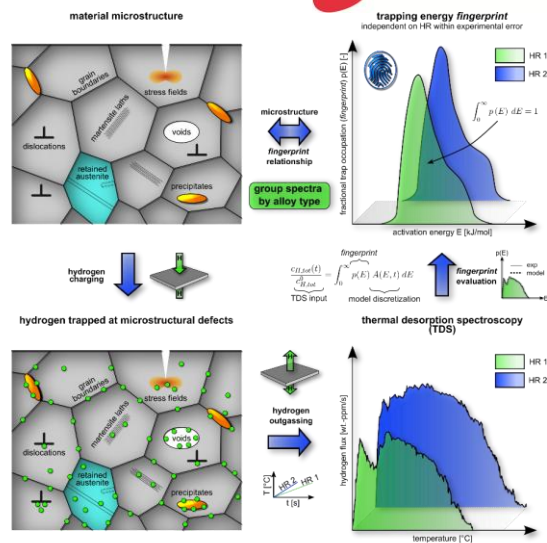


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Overview of the “Fingerprint” method. Image: <https://doi.org/10.1038/S41529-025-00718-Z>
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THE “FINGERPRINT” METHOD – NEW INSIGHTS INTO HYDROGEN IN STEEL

THE NEWLY DEVELOPED “FINGERPRINT” METHOD FOR ANALYZING H₂ DESORPTION MEASUREMENTS ENABLES FASTER DEVELOPMENT OF HYDROGEN-RESISTANT ALLOYS FOR THE ENERGY TRANSITION.

Hydrogen, as the smallest atom, is not only a key focus of the energy transition but can also cause unpredictable failures in steels, known as hydrogen embrittlement. Whether through corrosion or contact with hydrogen gas, steels can absorb hydrogen and fail prematurely. A central factor is the accumulation of hydrogen at grain boundaries, dislocations, and cracks, which leads to material embrittlement and is promoted by hydrogen’s small size and high mobility.

Because hydrogen is difficult to detect directly due to its size, indirect methods are often used to study its interaction with the microstructure. Temperature-programmed hydrogen desorption is particularly important and well established. In this method, the measured spectrum of hydrogen release versus

temperature is decomposed into several components using Gaussian curves. These components are attributed to specific microstructural features (such as grain boundaries, dislocations, precipitates, etc.) and interpreted in terms of their interaction energies with hydrogen. However, this requires measuring the spectrum at least three different heating rates, as well as prior knowledge of the number of curves to be used (i.e., the number of microstructural features). In addition, the Gaussian shape of the component curves has long been controversial, and each microstructural feature is assigned a single average interaction energy with hydrogen.

These key limitations have remained unchanged since the introduction of the established analysis method in 1982. Through interdisciplinary research, MCL, in

SUCCESS STORY

collaboration with Ghent University (Belgium) and the Christian Doppler Laboratory for Digital Material Design Guidelines to Prevent Alloy Embrittlement, has now succeeded in overcoming these limitations. The associated publication in the journal *npj Materials Degradation* (see image above) describes the novel “fingerprint” method, which enables full characterization of hydrogen-microstructure interactions based on hydrogen desorption measurements at a single heating rate. It also eliminates the need for prior knowledge of the exact number of microstructural features. Furthermore, the analysis result, the hydrogen “fingerprint”, represents a distribution of hydrogen interaction energies, providing deeper insights into hydrogen behavior in steels than the previously determined average energy values.

The concept of the “fingerprint” method was presented at the renowned Steel & Hydrogen conference (5th International Conference on Metals and Hydrogen) in Ghent, where it received the award for best poster after evaluation by an international expert jury.

Impacts and Effects

The newly developed “fingerprint” method allows hydrogen embrittlement-resistant alloys to be developed more quickly and in a more targeted manner, thereby increasing the safety of materials in contact with hydrogen and contributing to the energy transition. In collaboration with voestalpine, a corresponding patent is currently being filed, which has the potential to establish a new product group.



Best Poster Award for doctoral candidate Philipp Hammer at the Steel & Hydrogen Conference 2025 for the “Fingerprint” method. Bild: MCL

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