INTEGRATED ANALYSIS OF HYDROGEN EMBRITTLEMENT MECHANISMS OF A STEEL FROM ITS MECHANICAL BEHAVIOURS AND ATOM PROBE TOMOGRAPHY

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Tackling the hydrogen embrittlement (HE) phenomenon by direct observation of hydrogen in metallic materials has been a long-standing challenge for hydrogen being the lightest element. Atom probe tomography (APT) has been used as a practical microscopy approach to observe the hydrogen-metal interaction at a near-atomic level [1, 2] and has become more popular in the past decades or so [3, 4]. However, an expensive and complicated cryogenic and ultra-high vacuum transfer system is usually required to combat the fast diffusion and/or low solubility of hydrogen in metals, especially in body-centred cubic (bcc) iron. Here, we developed a simple and fast approach to achieve hydrogen observation in APT without special equipment required.
We used a FeAlMnTiC bcc ferrite as an example. Our approach enabled the integrated analysis of HE mechanical behaviours with APT analysis for the first time, providing an insight into the link between the HE mechanisms to the directly-observed H/D trapping sites. Our results show that the current steel suffered HE from grain boundary decohesion. The primary trapping sites interior of the grains were at the TiC/ferrite interfaces and along the dislocations hindered by the TiC; however, both the trapping sites might have complicated and dual influences on the HE. The size of the TiC precipitates, and the coherency of different TiC/ferrite interfaces significantly impacted the trapping nature.To increase the HE resistance of the steel, growing the precipitates into coarse and less coherent particles may be adopted, while the dislocation-precipitate interaction should also be considered.

References

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