1666
doi:10.1017/S1431927622006638

Microsc. Microanal. 28 (Suppl 1), 2022

Quantification of Hydrogen in Metals Applying Neutron Imaging Techniques

Nikolay Kardjilov[1*], André Hilger[1], Henning Markötter[2], Axel Griesche[2], Robin Woracek[3], Felix Heubner[4], Lars Röntzsch[4], Mirco Grosse[5], Ingo Manke[1], John Banhart[1,6]

[1.] Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Hahn-Meitner-Platz 1, 14109, Berlin, Germany;
[2.] Bundesanstalt für Materialforschung und -Prüfung, Unter Den Eichen 87, 12205, Berlin, Germany;
[3.] European Spallation Source ESS ERIC, SE-221 00, Lund, Sweden;
[4.] Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Branch Lab Dresden, Winterbergstraße 28, 01277, Dresden, Germany;
[5.] Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, Eggenstein-Leopoldshafen 76344, Germany;
[6.] Technische Universität Berlin, Straße des 17. Juni 135, 10623, Berlin, Germany;
[*]Corresponding author: kardjilov@helmholtz-berlin.de

Hydrogen interaction with metals is well known to have severe detrimental effects on their mechanical properties. The use of modern high-strength steels, which are attractive to improve fuel economy by reducing weight as well as candidates for H storage cylinders and other components, is currently being severely limited by the fact that the presence of H can cause embrittlement of the material. In addition to steel, several other metals and alloys used in the nuclear industry, like Ti and Zr, are susceptible to H degradation through hydride formation and subsequent cracking.

Microstructure-specific H mapping has been recognized as the most important challenge on the pathway towards a better understanding of the nature of H embrittlement in metallic alloys [1,2] as well as the development of H storage solutions based on metal hydrides [3]. Unfortunately, the characterization of H interactions with metals is an extremely challenging task and neutron-based techniques are of exceptional importance in this matter because – contrary to X-rays and electrons – thermal and cold neutrons interact strongly with the H nuclei [4], while the neutron beam is only weakly attenuated by the relevant metallic materials. Therefore, hydrogen distributions can be measured and quantified even in 3D by tomographic methods [5].

Here we present several neutron imaging investigations of embrittlement and cracking in Fe and Zr based metal alloys and optimization studies of hydrogen storage systems containing metal hydrides as an active substance. The advantages and the limitations of the experimental methods as well as the attempts for hydrogen quantification will be discussed in detail.

References:

[1] A. Griesche et al., Acta Materialia **78** (2014), 14-22.
[2] M. Grosse et al., International Journal of Materials Research **111.1**, (2020), 40-46.
[3] F. Heubner et al., Journal of Power Sources **397** (2018), 262-270.
[4] J. Banhart (Ed.). Advanced tomographic methods in materials research and engineering Vol. **66** (2008).

[5] N. Kardjilov et al., Materials Today **21** (2018), 652-672