MSE 2024

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Topic S: Structural Materials

S10: Recent Development in Metallic Materials for Sustainable Hydrogen Energy

Driven by the high potential of hydrogen technologies to support the transition to sustainable green energy industries, material development across the hydrogen supply chain, e.g. hydrogen generation infrastructure, hydrogen storage, hydrogen transportation, has gained great attention in the last decade. One hot topic has been the use of hydrogen as an energy vector i.e., for powering fuel cells in cars or trains, or piped into home appliances as a substitute for natural gas. Another important use for hydrogen is in heavy industry e.g., in green steel production, where H2 is being examined as a lasting alternative to extract iron from its ore. Regardless of the final application, hydrogen needs to be stored and transported to the point of use. For efficient H2 storage and transportation, innovative metallic materials are required. These materials must achieve specific properties e.g., resistance to hydrogen embrittlement, tolerance to very low temperatures (for liquid H2), higher strength (often required for lightweighting), and good storage density or reversibility (for solid state H2 storage).

This symposium addresses the recent progress of fundamental research of future materials and the current-in-use materials, e.g. material redesign by defect engineering, dopants, etc, for hydrogen applications. Topics on hydrogen uptake, diffusion, and trapping, hydrogen effect on material integrity, i.e. hydrogen embrittlement, surface reactions, as well as the development of novel advanced hydrogen-tolerant metallic materials using multi-scale and multi-spatial experimental and simulation approaches are very much welcome. This symposium aims to bring together interdisciplinary engineers and researchers who are dedicated to advancing the fundamental and applied research on hydrogen effects in metallic materials, and serve them a platform for sharing knowledge, discussing cutting-edge methodology and exchanging research experience.

- Exemplary topics and contributions are sought at the symposium include but are not limited to:
- Novel materials design and processes for H2 energy, e.g., H2 production, metal hydride systems for solid state H2 storage, liquid hydrogen transportation, combustion, etc.
- Impact of environmental conditions (e.g., in the presence of gaseous H2 or H2 generated from electrochemical reactions, low temperature, high pressure) on the hydrogen embrittlement sensitivity and on mechanical properties degradation of metallic materials.
- Characterization of hydrogen - metal interaction, hydrogen diffusion and trapping, as well as evaluating compatibility or performance of metallic materials in H2, using both experiments and simulations, including simulations from atomic up to the structural scale, e.g., density functional theory (DFT), molecular dynamics (MD) and kinetic Monte Carlo (KMC) simulations, finite element modeling (FEM), etc. and advanced characterization technology/testing methods, e.g., using sub-size specimens, thermal desorption spectroscopy (TDA), high-resolution transmission electron microscopy (HRTEM), atom probe tomography (APT) and slow strain rate tensile (SSRT) test.
- Weldability and joint performance of metallic materials for H2 pressure vessels and pipes.
- Fundamental research by numerical modelling of hydrogen diffusion in metallic materials and fracture to predict hydrogen induced failures and analyze the influence of process parameters on hydrogen embrittlement.
- Development of next generation hydrogen-mobility and hydrogen-safety metallic materials for lightweight hydrogen storage and transport.
- Design of hydrogen-tolerant metallic materials by artificial intelligence-aided approaches.

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