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Metal-Microwave Plasma interaction for Hydrogen Storage

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This work is a proof of concept for an efficient, fast and reversible cyclic hydrogen storage principle under ambient conditions for energy storage and next generation transportation systems. It consists of using the interaction between plasma and nanometric metallic materials instead of wide spread techniques. The choice of Ni results from their ability to store hydrogen trough an hydrogenation process as pure or alloyed particles. The special features of the stable nanomaterial (<100 nm) structure of nickel is (i) the fast ingress and transport of hydrogen along grain boundaries and triple junctions (short-circuit diffusion) and (ii) the enhancement of the intrinsic dislocations and vacancies density on trapping mechanisms. We use an ECR microwave sources to generate reactive plasmas. These engineered nanomaterials, submitted to cold plasma assisted hydrogen implantation should adsorb hydrogen for shorter interacting time. It was Indeed established that, ion implantation produces hydrogenated phases in nickel. In practice, thin pellets will be used for plasma treatment to be loaded in H thanks to hydride formation. Parameters of the hydrogen charging plasma has been carefully studied (ions density, energy and flux) to optimize the implantation procedure, to analyze the induced structural modifications due to hydrogen penetration, and on the aging due to cycling, which could lead to a significant variation of the hydrogen retention capability. These experiments has been assisted by the development of a new 3D numerical tool, coupling non-equilibrium kinetic hydrogen transport and trapping, mechanical field evolution, and the induced damages in material. This model enable to predict transient hydrogen inventory and embrittlement of the bulk. It will allow to simulate the total retained hydrogen; depth profiles of solute and trapped hydrogen; and the temperature distribution in the exposed material over the time.

Keywords
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