Filling the gap with solid-state hydrogen storage: stable metal-hydrogen structure for the hydrogen economy

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To drive a decarbonization, the development of sustainable energy systems is required, and hydrogen is considered a future energy vector for climate neutrality. The renewable energy systems such as solar and wind energy suffer from the intermittency in production, influenced by environmental, seasonal and daily cycles. Hydrogen can play a key role in resolving such issue, serving as an ideal energy carrier and also fuel. To expedite the hydrogen economy, one of the critical technologies is safe and efficient hydrogen storage, which bridges the gap between hydrogen production and utilization. Metal hydrides such as MgH_2 and various Ti-based alloys have been studied as a promising candidate for solid-state hydrogen storage, yet their implementation into practical applications is limited due to the restricted thermodynamic and kinetic properties related to hydrogen storage as well as the instability under ambient conditions. We aim to tune various metal-hydrogen structures for stable and efficient hydrogen storage systems. To control thermodynamics and kinetics associated with hydrogen sorption reaction in metal hydrides, a variety of strategies are formulated such as the introduction of transition metal moieties, the formation of hybrid structure with scaffolds, and the reduction of particle size. More importantly, gas-selective layers can be introduced on the surface of metal hydrides for their use under ambient conditions, preventing the extensive oxidation. With a synergistic effect of such material design, hydrogen storage performance is greatly improved, simultaneously achieving the environmental stability. We believe that the advanced metal-hydrogen structure can facilitate the development of sustainable energy system for the future net-zero transition.