

new metal matrices. Modification of alloys using intensive plastic deformation, catalytic additives and optimization of solid solutions opens up ways to improve the reversible capacity and resistance of materials to impurity poisoning. High-entropy alloys (HEAs), which, due to the unique effects of crystal lattice distortion, demonstrate high hydrogen capacity. Further development of these technologies and optimization of alloy compositions will allow the creation of highly efficient and cost-effective solid-state hydrogen storage devices.

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**HIGH-ENTROPIC ALLOYS AS A NOVEL MATERIAL FOR SOLID-STATE
HYDROGEN STORAGE**

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The global energy transition requires the development of safe and highly efficient hydrogen storage technologies. Traditional metal hydrides are being replaced by innovative multi-component metal systems. The current paradigm for the development of materials for solid-state hydrogen storage is shifting towards high-entropy alloys (HEA),

which offer a unique platform to overcome the limitations of traditional systems. The design of such alloys is based on the precise control of thermodynamic parameters, in particular the difference in atomic radii δ , the enthalpy of mixing (ΔH_{mix}) and the valence electron concentration (VEC), which allows predicting the phase stability of complex multi-component systems. It has been established that the formation of a body-centered cubic (BCC) structure is a key factor for efficiency. Due to the low packing ratio (0.68) and significant lattice distortion, the BCC phase provides expanded space in the tetrahedral and octahedral interstitials, which contributes to a high diffusion rate and a record hydrogen to metal ratio (H/M up to 2.5), as observed in the Ti-V-Zr-Nb-Hf system [1].

The technological aspect of HEA production plays a critical role in ensuring their operational characteristics. The use of advanced methods, such as laser deposition (LENS), spark plasma sintering (SPS) and mechanical alloying, allows obtaining alloys with a microstructure that is as close as possible to the theoretically calculated one. In particular, for systems such as Ti-Al-Nb, optimal SPS modes (at 1300 °C) contribute to the formation of stable two-phase structures (B2 + O), where hydrogen diffusion is facilitated through grain boundaries and interlamellar interfaces [2]. At the same time, the variation of the chemical composition allows to control the phase formation: if Ti, V and Cr act as stabilizers of the BCC phase, then the addition of Fe effectively suppresses the formation of brittle σ phases, increasing the plasticity. It has been established that for the $Ti_{0.2}V_{0.2}Zr_{0.2}Nb_{0.2}Hf_{0.2}$ alloy, which is characterized by a BCC structure, the capacity is 1.94 wt.% H at 573 K, and doping with magnesium (Mg) significantly improves the cyclic stability of refractory systems [3].

Recent studies in the field of medium entropy alloys (MEA), in particular Al-Ti-Nb systems with the addition of Zr, V or Hf, have revealed a fundamental regularity: the sorption capacity of the material is inversely correlated with its microhardness. The high strength of interatomic bonds creates an energy barrier for the penetration of hydrogen into the lattice, which makes less hard alloys more effective absorbents. The most promising representative of this class is the $Al_{15}Ti_{40}Nb_{30}Zr_{15}$ alloy, which combines a reversible capacity of 1.03 wt.% H with low weight (23% lighter than $LaNi_5$) and the absence of precious rare earth elements. Thus, the synergy of compositional design and

strict adherence to synthesis parameters opens the way to the creation of a new generation of lightweight and capacious hydrogen storage [4].

Thus, the creation of high-entropy (HEA) alloys allows you to control the energetics of the metal-hydrogen bond. This lays a solid foundation for scaling environmentally friendly energy installations.

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