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Investigation of Titanium, Zirconium, Vanadium, and Palladium Multilayer Systems for Advanced Hydrogen Storage Applications

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Interest in utilizing solid materials for hydrogen storage has grown in recent years due to the necessity of reducing greenhouse gas emissions by harnessing hydrogen as an energy source. While this approach is generally regarded as safe, significant challenges remain in developing materials that are effective, easily synthesized, cost-efficient, highly stable, and exhibit rapid sorption kinetics. Moreover, the presence of oxides can considerably diminish the efficiency of potential solid materials designated for this purpose. In this study, we examined multi-layered systems comprised of thin films of titanium (Ti), zirconium (Zr), vanadium (V), and palladium (Pd) for hydrogen storage applications. Through the elastic recoil detection analysis (ERDA) technique, we found that the hydrogen content decreased as the oxygen concentration in the layers increased, underscoring the detrimental impact of oxygen on the system. Specifically, samples with a titanium oxide (TiO) ratio of 1:1 and vanadium oxide (VO) ratio of 1:1 exhibited a total hydrogen content of 99.122 atomic percent (at.%) at 200 ℃, whereas those with titanium trioxide (Ti2O3) at a 2:3 ratio and vanadium trioxide (V2O3) at a 2:3 ratio displayed a reduced hydrogen content of 60.016 at.% at 300 ℃, indicating a substantial change. The optimal temperature range for achieving the highest hydrogen content was determined to be between 200 ℃ and 300 ℃. To address the adverse effects of oxides, we propose employing an ion implantation mechanism in conjunction with in-situ thermal annealing to create oxygen-free samples for testing in hydrogen storage applications. The outcomes of this investigation, along with the proposed mechanisms, are presented and discussed.

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