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Enhanced Green Hydrogen Production Using ALD-based Catalysts for Ammonia Decomposition

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Ammonia-based hydrogen value chains are emerging as one of the most promising ways for achieving a carbon-neutral hydrogen economy. In order to expedite the development, it is essential to develop highly efficient and scalable catalysts for ammonia decomposition. In this study, we demonstrate the use of atomic layer deposition (ALD) to fabricate highly efficient Ru/TiO_2-ALD/γ-Al_2O_3 bead catalysts for ammonia decomposition. By utilizing the ALD technique to introduce an ultrathin TiO_2 layer between Ru nanoparticles and the γ-Al_2O_3, followed by high-temperature alloying, we were able to change the electronic structure of the Ru and shift the nitrogen binding energy to lower, resulting in an enhancement of catalytic activity. One of the most intriguing aspects of this study is the use of ALD technology to overcome the limitations of reducible oxides in high-temperature reducing atmospheres, such as particle encapsulation or consolidation that can diminish the catalytic activity of nanoparticles. Compared to state-of-the-art Ru-based catalysts with rare-earth metal oxides such as Y_2O_3 and La_2O_3, the Ru/ALD-TiO_2/γ-Al_2O_3 catalysts developed in this study demonstrated superior catalytic performance as well as cost competitiveness due to minimized utilization of functional oxide. The promising results of this study indicate that the use of ALD technology catalysts has the potential to significantly advance the establishment of ammonia-based hydrogen value chains, leading to enhanced efficiency in the hydrogen reconversion process and ultimately reducing the levelized cost of hydrogen.