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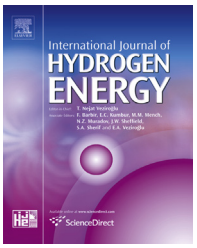

Review Article

A review on the current progress of metal hydrides material for solid-state hydrogen storage applications

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ABSTRACT

Energy is one of the basic requirements in our daily lives. Daily activities such as cooking, cleaning, working on the computer and commuting to work are more or less dependent on energy. The world's energy demand is continuously increasing over the years due to the ever-increasing growth in the human population as well as economic development. At present, approximately 90% of energy demands are fulfilled by fossil fuels. With the rising demands of energy throughout the globe, it can be expected that the availability of fossil fuels is depleting at an alarming rate since fossil fuels are non-renewable sources of energy. In addition, fossil fuels are the main contributor of greenhouse gas emissions and therefore, they have a detrimental impact on human health and environment in the long term. Hence, there is a critical need to develop alternative sources of energy in replacement of fossil fuels. Hydrogen fuels have gained much interest among researchers all over the world since they are clean, non-toxic and renewable, making them suitable for use as substitutes for petroleum-derived fuels in vehicular applications. However, the greatest challenge in using hydrogen fuels lies in the development of hydrogen storage systems, especially for on-board applications. Hydrogen fuels can be stored in gaseous, liquid or solid states, and much effort has been made to develop hydrogen storage systems that are safe, cost-effective, environmental-friendly and more importantly, with high energy densities. Current technologies used for hydrogen storage include high-pressure compression at about 70 MPa, liquefaction at cryogenic temperatures (20 K) and absorption into solid state compounds. Among the three types of hydrogen storage technologies, the storage of hydrogen in solid state compounds appears to be the most feasible solution since it is a safer and more convenient method compared to high-pressure compression and liquefaction technologies. In this regard, metal hydrides are potential chemical compounds for solid-state hydrogen storage, and a large number of studies have been carried out to synthesize low-cost metal hydrides with low absorption/desorption temperatures, high gravimetric and volumetric hydrogen storage densities, good resistance to oxidation, good reversibility and cyclic ability, fast kinetics and reactivity, and moderate thermodynamic

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stability. In general, these studies have shown that the absorption/desorption properties of hydrogen can be improved by: (1) the addition of catalysts into the metal hydrides, (2) alloying the metal hydrides, or (3) nanostructuring. This review article is focused on the latest developments of metal hydrides for solid-state hydrogen storage applications, which will be of interest to scientists, researchers, and practitioners in this field.

Contents

Introduction

The escalating growth of the human population and rapid evolution of heavy industrial sectors results in a continuing increase in energy demands [1]. In order to fulfil the ever-increasing energy demands, current and future energy systems should be cost-effective, practical, reliable and sustainable, with low impact on the environment [2]. The depletion of fossil fuels and other non-renewable energy sources is a prevalent issue [3], and one of the greatest challenges nowadays is to develop energy systems which will fulfil energy demands by harnessing energy from renewable and sustainable sources [4]. Even though fossil fuels are widely used for energy provision, the burning of fossil fuels also releases high amounts of greenhouse gas emissions (resulting in air pollution and global warming) and have detrimental impact on ecological systems [5]. Hence, scientists and researchers strive continuously to develop energy systems which harness energy from renewable and sustainable sources such as solar, wind, wave and geothermal energy. Solar and wind energy are generally dependent on weather conditions. Wave energy is harnessed from the oceans whereas geothermal energy is harnessed from the hot rocks and fluids within the Earth's crust, and therefore these two forms of energy are generally location-dependent. More importantly, these sources of energy are difficult to store and transport [6].

For these reasons, there is growing interest in hydrogen fuel-based technologies in recent years. Hydrogen is a

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