Advanced Materials Research Vol. 925 (2014) pp 200-204

doi:10.4028/www.scientific.net/AMR.925.200

Photocatalytic Hydrogen Production from Water on Ga, Sn-doped ZnS under Visible Light Irradiation

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Keywords: Ga(*0.1*), Sn(*x*)-ZnS, photocatalyst, dopant, hydrogen, visible light

Abstract. Zinc sulfide (ZnS) has been reported to act as a photocatalyts to reduce water to hydrogen. However, ZnS could not work under visible light irradiation due to its large band gap energy. In order to improve the performance of ZnS, Ga and Sn were doped to ZnS. The series of Ga(*0.1*),Sn(*x*)-ZnS with various amounts of Sn (*x*) was prepared by hydrothermal method. XRD patterns suggested that the addition of Ga might reduce the crystallinity of ZnS, suggesting that Ga might inhibit the crystal growth or agglomeration of ZnS. On the other hand addition of Sn did not much affect the structure of the Ga(*0.1*)-ZnS. The DR UU-visible spectra confirmed the red shift of the absorption edge with the addition of Ga due to the reduced band gap energy, while the addition of Sn did not much shift the absorption edge of the Ga(*0.1*)-ZnS to longer wavelength. FESEM images showed that all the prepared samples have sphere-shaped particles and no remarkable change was observed with the addition of Ga or Sn. The photocatalytic hydrogen production from water was carried out at room temperature in the presence of sacrificial agent under visible light irradiation. While ZnS did not show activity under visible light, all the prepared Ga(*0.1*)-ZnS and Ga(*0.1*),Sn(*x*)-ZnS samples exhibited photocatalytic activity for hydrogen production. The highest hydrogen production was achieved on Ga(*0.1*),Sn(*0.01*)-ZnS, which activity was *ca.* three times higher than that of the single doped Ga(*0.1*)-ZnS. This study clearly showed that Sn acted as a good co-dopant to increase the photocatalytic activity of Ga(*0.1*)-ZnS for hydrogen production from water under visible light irradiation.

Introduction

Hydrogen is one of the cleanest energy since it does not involve carbon emission. In order to sustain the production of hydrogen, the use of both renewable source and sustainable process must be concerned. Photocatalytic water splitting would be one of the best approaches to produce hydrogen [1, 2] using renewable water source and sustainable photocatalytic process, which only requires photocatalyst, light, and mild conditions such as room temperature. Due to the strong demand to utilize solar light, which consists of large portion of visible light region, the development of visible light-active photocatalysts has been recognized as the important approach in photocatalysis field nowadays. In this work, UV-active zinc sulfide (ZnS) was modified so that it could work under visible light irradiation.

ZnS is one of the reported photocatalysts for hydrogen production from water in the presence of sacrificial agents [3, 4]. It has been reported that the high activity of ZnS can be achieved even without addition of co-catalyst, due to the high conduction band of ZnS and its rapid generation of electron-hole pairs to reduce water to hydrogen. However, unfortunately, the large band gap energy has restricted the use of ZnS only within the UV light region. Therefore, the modification of ZnS is highly required to improve its performance under visible light irradiation. Doping of ZnS would be one of the best methods to reduce the band gap energy without changing the high conduction band