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The impact of swift heavy ion irradiation on bismuth vanadate photoanode for photoelectrochemical water oxidation

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Photoelectrochemical (PEC) water splitting is a promising method for environmentaly benign production of energy in the form of chemical fuels. Monoclinic bismuth vanadate (BiVO4) stands out as an excellent candidate for photoanode material due to its suitable band structure, good stability and low-cost synthesis. However, BiVO4 has poor charge transfer properties due to the high rate of electron-hole recombination and understanding the effects contributing to it is important for further improvements. Herein, we report the effect of swift heavy ion irradiation (Xe, 150 MeV, 1 × 1010 −5 × 1011 ions/cm2) on physicochemical properties of hydrothermally synthesized BiVO4 thin films. X-ray diffraction study (XRD) showed that irradiated material preserved initial monoclinic scheelite phase and preferential growth along [010] direction together with the presence of notable amorphization for 5 × 1011 ions/cm2 irradiated sample. Scanning electron microscopy (SEM) of all samples showed prismatic grains with an average size of 600 nm. In irradiated samples formation of ion tracks, ~ 10 nm in diameter, was observed. Raman spectroscopy analysis confirmed presence of bands that correspond to the monoclinic scheelite phase along with the appearance of new bands for 5 × 1011 BiVO4 at 420 and 915 cm-1. X-ray photoelectron spectroscopy (XPS) analysis of Bi 4f, V 2p and O 1s states showed that, after irradiation, increased amounts of V4+ and oxygen vacancies occured, especially at higher fluences. By using UV-Vis Diffuse Reflectance spectroscopy we showed that band gap decreased with the increase in fluence. Photocurrent densities, obtained from 1-hour-long chronoamperometry measurements, indicated that irradiation with 1 × 1010 ions/cm2 fluence leads to the enhanced PEC oxygen evolution with time. In order to get a better insight into preceding phenomena, we performed XRD, SEM and XPS analysis after PEC processs.

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