Oxygen Partial Pressure Dependence Effect to Mo-doped $BiVO_4$ Thin-Film Photoanode Performance Sputtered by Single Target Radio Frequency

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$BiVO_4$ (Bismuth Vanadate) is n-type semiconductor and sustainability inspired photoanode material with a suitable bandgap for visible light absorption and oxygen evolution reaction (OER). However, due to the fast charge carrier recombination, the photocatalytic efficiency of $BiVO_4$ is strongly limited by low electron mobility. Incorporating additives as a dopant is a common pathway to fine-tune the physical properties of semiconducting materials [1]. In the case of $BiVO_4$, particular attention was paid to molybdenum (Mo) dopants is expected to be incorporated substitutionally at the V site and act as donors. Improved n-type conductivity, effective charge separation, and catalytically active surface states are commonly proposed to the Mo:$BiVO_4$ [2]. Considering the rapid development of thin film photoanode fabrication, radio frequency sputtering could be a scalable preference for industrialization acceleration. In addition, sputtering from a single target is beneficial to control the ratio balance of the sputtered film improving the film quality. Herein, we introduce the Mo doped to the $BiVO_4$ film by single target sputtering fabrication with respect to the oxygen partial pressure percentage to improve the performance of photoanode water splitting.

All films were deposited using Bi_2O_3:V_2O_5:MoO_3 single target on conductive glass (Fluorine-doped Tin Oxide by RF (Radio Frequency) sputtering process. The films were loaded by appropriate growth condition concerning on oxygen partial pressure percentage (O_2/(O_2+Ar) = 5%, 10%, 15%, and 20%) dependence to apply the target on the surface in high temperature. The fabrication were done with fixed 0.7 Pa total pressure in the chamber.

By different oxygen partial pressure, the films were controlled by different composition of Bi, V and Mo elements. The atomic ratio of V and Mo in the films have increased along with oxygen partial pressure increasing, shown in fig 1. The V-rich films support the good crystallinity to enhance the PEC (Photoelectrochemical) performance [3]. The ratio balance of the film could affect the crystal structure and electronic properties of photoanode supporting the acceleration of carriers. Thus, the moderate Mo doping of $BiVO_4$ can improve the film quality and photocurrent density of PEC water splitting. In agreement to the PEC performance shown in Fig 2, the photocurrent density enhance from 0.2 to the 1.06 mA/cm^2 at 1.23V vs reversible hydrogen electrode (RHE) by Mo-doped in 15% O_2. In conclusion, the performance of photoanode film could be improved by doping ratio which was controlled by adjustment the oxygen partial pressure during deposition.

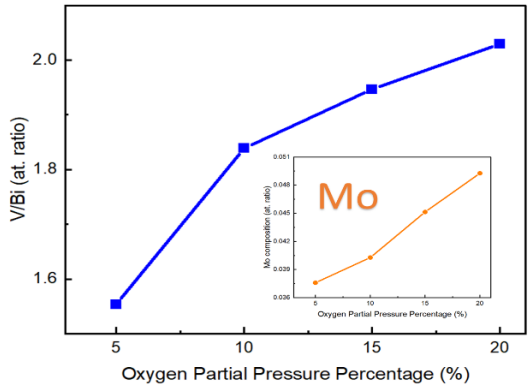

Figure 1. Film Composition with respect to the oxygen partial pressure

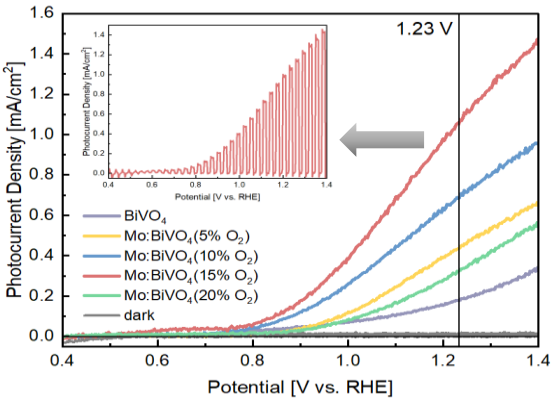

Figure 2. PEC Performance with simulated AM 1.5 solar illumination

References

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