Morphology-tailored fabrication of microdisc WO_3 arrays for improving Photoelectrochemical water oxidation

Hye Won Jeong[1,2], Yiseul Park[3], Hyunwoong Park [1,2]

[1] School of Civil, Architectural, Environmental, and Energy Engineering, Kyungpook National University, Daegu, Korea

[2] School of Energy Engineering, Kyungpook National University, Daegu, Korea

[3]Department of Chemical Engineering, Pukyong National University, Pusan, Korea

E-mail: hwj1012@gmail.com

Photoelectrochemical water oxidation is a necessary for sustainable solar fuel production. However, the overall solar conversion efficiency is limited by rapid charge recombination on the photoanodes. Modifications of metal oxide, especially, one- to three-dimensional alignments of metal oxide have been affected the transfer pathways and kinetics of photogenerated charge carrier. Here, for the first time, we report the fabrication of well-aligned WO_3 microdisc array by electrodeposition method on patterned indium tin oxide (ITO) substrate. As-prepared WO_3 microdisc array exhibits enhancement of light absorption and charge transfer showing higher PEC performance than that of WO_3 films. A finite-difference time-domain simulation of a single WO_3 microdisc indicates that the strong optical resonances occur particularly in the central part of the microdisc, leading to enhanced optical absorption. Time-resolved photoluminescence study further reveals that the averaged lifetime of charge carriers (τ) in a microdisc array is shorter than that in a film by ~60%. The reductively deposited Au particles and oxidative deposition of FeOOH particles suggests the separated transfer pathways of the photogenerated electrons and holes. This dissimilar transfer pathway of the charge carriers lead to efficient charge separation, and the surface-specific reactivity of WO_3 microdisc arrays should be advantage to spatially separated oxidation and reduction reactions with high efficiency.