Electrochemical synthesis of Cuprous Oxide on High Conducting Metal Micro-pillar Arrays for Water splitting

Sanghwa Yoon1, Jae-hong Lim2, and Bongyoung Yoo1,*,

1Department of Materials Engineering, Hanyang University, Ansan-si, Gyeonggi-do, 426-791, Republic of Korea
2Electrochemistry Research Group, Materials Processing Division, Korea Institute of Materials Science, Changwon-si, Gyeongnam, 641-831, Republic of Korea

Hydrogen is a critical energy source, when it combines with oxygen (H2 + 1/2O2 → H2O + energy) in fuel cell. Photoelectrochemical (PEC) water splitting using sunlight directly is an attractive and suitable technology for producing of hydrogen as well as oxygen. PEC cell consisting of two electrodes in an aqueous electrolyte is working based on the semiconductor and liquid junction.1,2

A p-type cuprous oxide (Cu2O) with a direct bandgap energy of 2.1eV is one of the promising materials for a photoelectrode of PEC cell. Despite the theoretical maximum photocurrent and solar to hydrogen conversion efficiency as ~-14.7mAcm-2 and 20%, remarkably low photocurrent and conversion efficiency were recorded at electrodeposited Cu2O films. One of many negative factors of Cu2O device performance is the short minority-carrier diffusion length in electrodeposited Cu2O (20-100nm) compared with long light adsorption depth of ~10μm. To approach the theoretical maximum efficiency, high aspect ratio of ~250 is critically required.3,4

In the present study, we fabricated Cu2O/Au/Ni micro-pillar arrays simply. First, the Si micro-pillar arrays were fabricated by commercial photolithograph method. The height and pitch of nickel micro-pillar were about 15 μm and 4 μm. Then, the Si micro-pillar arrays were displaced by Ni metal after electroless deposition. For ohmic contact of Cu2O, the gold was electrodeposited on Ni micro-pillar arrays. Finally, Cu2O was synthesized by electrodeposition from aqueous copper (II)-citrate bath. Figure 1 shows the SEM images and X-ray diffraction pattern of Si and Cu2O pillar arrays films. The Cu2O was uniformly deposited on Au/Ni pillar and the thickness of Cu2O was 400nm. This pillar structure provides high current pathways, reduction of minority carrier diffusion length and light scattering and trapping. So, the photocurrent of Cu2O pillar arrays increases 2 times in comparison with that of Cu2O film (Fig. 2). The metal micro-pillar structure can be applied at different metal oxide materials such as CuO, Fe2O3, WO3, CuWO4 and BiVO4.