論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Galvanostatic Electrodeposition of ZnO Nanosheet as Photoanode in Dye Sensitized Solar Cell (DSSC)
著者(和文)	GeraldEnsangTimuda
Author(English)	Gerald Ensang Timuda
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11584号, 授与年月日:2020年9月25日, 学位の種別:課程博士, 審査員:脇 慶子,長﨑 孝夫,長谷川 純,和田 裕之,田巻 孝敬
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11584号, Conferred date:2020/9/25, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

2013.8改訂
Revised August 2013

（論文博士）
(Dissertation Doctorate)

論　文　要　旨（英 文）　（**800**語程度）

Dissertation Summary (approx. 800 words in English)

報告番号 For administrative use only	乙 第　　　　号	氏　名 Name	Gerald Ensang Timuda

（要　旨）
(Summary)

In this research, a novel approach to electrodeposit ZnO nanosheet will be presented using galvanostatic (constant current) mode instead of the commonly used potentiostatic (constant potential) mode. As far as our knowledge, this is the first report on the galvanostatic electrodeposition of ZnO nanosheet. In this research, the mechanism of the formation of the under-layer of the electrodeposited ZnO nanosheet which was not scrutinized in the previous report was also able to be revealed. It was found that the general structure of the galvanostatic electrodeposition samples has a nanosheet morphology, which is grown perpendicularly against the conductive (In-doped Tin Oxide, ITO) substrate. And, after sufficient deposition time, a specific type of under-layer are grown beneath the nanosheet. The electrodeposition using -1 mA/cm^2 produces a dense-like type of under-layer. Meanwhile, the -3 and -5 mA/cm^2 deposition produce a particle-like under-layer, in which the particle size of the -5mA/cm^2 seems to be smaller than the -3 mA/cm^2 deposition. The dense-like under-layer produce excellent bonding to the ITO substrate, as opposed to those observed for the particle-like under-layer. The particle-like under-layer became peeled off after long enough deposition time (300 s for -5 mA/cm^2 and 1500 s for -3 mA/cm^2 deposition) while not so for the dense-like under-layer (up to 10800 s for -1 mA/cm^2 deposition). The nanosheet height was grown as the majority part of the total structure for most cases, except

for those where the deposition time is too long (10800 s for -1 mA/cm^2 deposition). The nanosheet being grown contains zinc-acetate- and zinc-nitrate-complex ($Zn_5(CH_3COO)_2(OH)_8.2H_2O$ or ZAH, $Zn_x(CH_3COO)_y(OH)_z•nH_2O$ or ZAHH, and $Zn_5(OH)_8(NO_3)_2.2H_2O$ or ZNH) beside ZnO. Meanwhile, the under-layer part is very likely the product of the cathodic ZnO growth. The growth of the zinc-acetate-and zinc-nitrate-complexes were very likely faster than those of the ZnO one. Therefore, applying small current (-1 mA/cm^2) can well produce the dense-like structure of the under-layer with (002) preferred growth orientation. In contrary, increasing the deposition current (-3 and -5 mA/cm^2) increases the rate of the electrochemical reaction responsible for the ZnO growth which disturbs the preferred (002) growth thus produces a particle-like structure as the under-layer.

Upon application as the photo-anode for dye sensitized solar cell (DSSC), it has been shown that all the electrodeposited nanosheet samples show better performance than the DSSC made using commercial ZnO nanoparticle layer as photo-anode. Impedance Spectroscopy (IS) analysis revealed that the slope of the $C\mu$-V curve of the nanoparticle layer is quite different compared to those of nanosheet samples, indicating quite different trap states distribution between the nanoparticle and the nanosheet samples. The recombination resistances for the nanosheet structure are also much larger, which explain the solar cell performance. Among the DSSC samples utilizing nanosheet structure as the photo-anode, the taller nanosheet produces more dye loading which contributes to the increase in the short-circuit current density and performance. The specific type of under-layer gives effect also on solar cell performance. For the particle-like under-layer, the solar cell efficiency shows a decrease in value when the under-layer became more dominant/taller, which is not observed for the dense-like one.

ZnO nanosheet also has an opportunity to be applied as photoanode for perovskite solar cell and solar water splitting. For perovskite solar cells, the ZnO nanosheet structure can be utilized as a vessel where the perovskite crystal can grow inside. The concept is to be able to grow single crystal in the vessel so that the grain boundary usually present was replaced by the ZnO nanosheet walls to improve the electron collection. For photolysis, the ZnO nanosheet has been used as the photoanode to split water upon UV light illumination. The abrupt current-response is observed during on-off light illumination indicating a good photo-response. The morphology of the nanosheet seems to influence the photolysis properties since taller nanosheet can produce larger photocurrent, especially at large applied potential.