The study in thin film fabrication of nanocrystalline zinc oxide doped with bismuth for electron transport layer of perovskite solar cells

The electron transport layer (ETL) in perovskite solar cells (PSC) is an important part for transporting electrons (e⁻) from the perovskite layer (PS) to the electrodes when light strikes the cell, making PSC have higher power conversion efficiency (PCE) and electron collection. The ETL film, with good optical absorption (T%), lower reflection (R%), and better photovoltaic properties, must be prepared carefully. The research conducted the fabrication of thin film snc-ZnO:Bi for ETL of PSC using sol-gel technique, spin-coating, and rapid thermal annealing (RTA) at 700-930°C for 10-20 seconds. The film showed high transmittance (T%) and low reflection (R%) in the range of 250-850 nm, indicating good light absorption and electron transport properties. The film was then used in PSC with the structure Glass/ITO/snc-ZnO:Bi/CH₃NH₃PbI₃/Au, achieving a PCE of 0.57% under 1.77 mW/cm², with Jsc = 4.07 mA/cm², Voc = 465 mV, and FF = 0.302.
ผลลัพธ์แสดงให้เห็นว่าฟิล์มบางส่วน snc-ZnO:Bi สามารถนำมาพัฒนาเพื่อเป็นชั้น ETL ให้กับแสงอาทิตย์ชนิด PS ได้
NANOCRYSTALLINE ZINC OXIDE/ELECTRON TRANSPORT LAYER /PEROVSKITE SOLAR CELL

Electron transport layer (ETL) is an important part for accumulating electrons produced in perovskite (PS) to be delivered to its metal contact of perovskites solar cell (PSC). Under illumination test, PSC can provide the power conversion efficiency and additional electrons enhancement in the ETL which can respond with short wavelength light and high transmittance (%T). However, high ETL qualities in the terms of good electrical property, proper optical characterizations and good surface morphology have base on a high annealing dependence.

This research studies on the fabrication of ETL from spherical nano zinc oxide crystals doped with bismuth (snc-ZnO:Bi) for PSC application. ETLs were prepared by sol-gel of ZnO doped with Bi solution which was coated on an ITO/glass slide by spin coating. ETL films were sintered with varying conditions of a rapid thermal annealing (RTA) at 700-930°C for 10-20 seconds and a conventional annealing at 350-550°C for 2 hours into the atmosphere. The results illustrated that snc-ZnO:Bi films with RTA at 930°C for 20 seconds condition provide T% above 90% and reflectance (R%) below 3% in the wavelength range of 250-850 nm. The optical results reply to proper light-trapping of such ETL films. There are clearly invariable film thickness with no crack at
the surface. ETL contains the grain crystal size around 10-20 nm. Therefore, ETL produced from RTA provides the better quality of snc-ZnO:Bi than the conventional annealing. RTA can also improve ITO resistivity with a small sheet resistivity of 27 ohm/sheet comparing with the convention annealing.

In this study, snc-ZnO:Bi film was used for ETL in PSC (Glass/ITO/snc-ZnO:Bi/CH$_3$NH$_3$PbI$_3$/Au). The PS cells demonstrated with the diameter size of 0.0452 cm$^2$ provide short circuit current density ($J_{sc}$) of 4.07 mA/cm$^2$, open voltage ($V_{oc}$) of 455 mV and fill factor (FF) of 0.302 that lead to the power conversion efficiency of PSC at 0.57% under light intensity at 1.77 mW/cm$^2$. The electrical results of PSC indicate that snc-ZnO:Bi can be a candidate ETL for PSC application.