

## Fabrication of SnO<sub>2</sub> by RF magnetron sputtering for electron transport layer of planar perovskite solar cells

The requirements of electron transport layer (ETL) for high efficiency Perovskite solar cells (PSCs) are, for example, appropriate band energy alignment, high electron mobility, high optical transmittance, high stability, and easy processing. The metal-oxide ETLs that have been proposed for PSCs are, such as, TiO<sub>2</sub>, SnO<sub>2</sub>, etc. TiO<sub>2</sub> is usually used for ETL as a compact layer and a mesoporous layer. Both layers give relatively higher efficiency PSCs. However, TiO<sub>2</sub> layer has some limitations for PSCs such as it needs high-temperature process and yields low electron mobility. The effect of TiO<sub>2</sub> layer negatively affects the device stability under ultraviolet (UV) illumination. Recently, SnO<sub>2</sub> has attracted more attention as ETL for PSCs because it has diverse advantages, e.g., wide bandgap energy (3.5 –4.0 eV), excellent optical and chemical stability, high transparency, high electron mobility ( $\sim 240 \text{ cm}^2/\text{V.s}$ ), and easy preparation. The SnO<sub>2</sub> ETL was fabricated by RF magnetron sputtering technique to ensure the chemical composition and uniform layer thickness when compared to the use of chemical solution via spin-coating method. The RF power was varied from 60 –150 W. The Ar sputtering gas pressure was varied from  $1 \times 10^{-3}$  –  $6 \times 10^{-3}$  mbar while keeping O<sub>2</sub> partial pressure at  $1 \times 10^{-4}$  mbar. The thickness of SnO<sub>2</sub> layer decreases as the Ar gas pressure increases resulting in the increase of sheet resistance. The surface morphology and optical transmission of the SnO<sub>2</sub> ETL were investigated. It was found that the optimum thickness of SnO<sub>2</sub> layer was approximately 35 –40 nm. The best device shows  $J_{sc} = 27.4 \text{ mA/cm}^2$ ,  $V_{oc} = 1.03 \text{ V}$ , fill factor = 0.63, and efficiency = 17.7%.

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**Track Classification:** Surface, Interface and Thin Films