Optimization of NiO_x by sputtering as HTL for perovskite solar cells

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NiO_x appears as one of the most promising inorganic hole transport layers (HTL) for perovskite solar cells. It exhibits high optical transparency, a large band gap, good stability, and relatively low cost. It has been extensively investigated and intense efforts have been specifically dedicated to improving its intrinsic low conductivity at room temperature. Indeed, pure stoichiometric NiO is insulating. Tuning the deposition parameters, and particularly controlling the oxygen injection, is paramount to make NiO_x an efficient hole transport layer. Different deposition techniques have been investigated to produce high quality NiO_x films, such as ALD, magnetron sputtering, PLD, CBD, spray pyrolysis etc. Among them, magnetron sputtering appears as one of the most suitable techniques for industrial manufacturing. It is a versatile, conformal and low temperature deposition technique with fast deposition rate. Recent studies have reported promising results of sputtered NiO_x in semi-transparent PIN solar cells.[1–3]

This work aims at optimizing the sputtering parameters of NiO_x through, first, a material study, and then the integration of NiO_x films in semi-transparent PIN perovskite solar cells (PSC). Specific attention will be inclined toward the effect of oxygen ratio introduced during the deposition as well as the effect of post-annealing treatments on the surface morphology, structural and optical properties of NiO_x (Figure 1a-b). These effects are also investigated through the general performances of semi-transparent PIN PSC (Figure 1c), for which the first tests with sp-NiOx as HTL showed promising results with an efficiency of 13.8%.

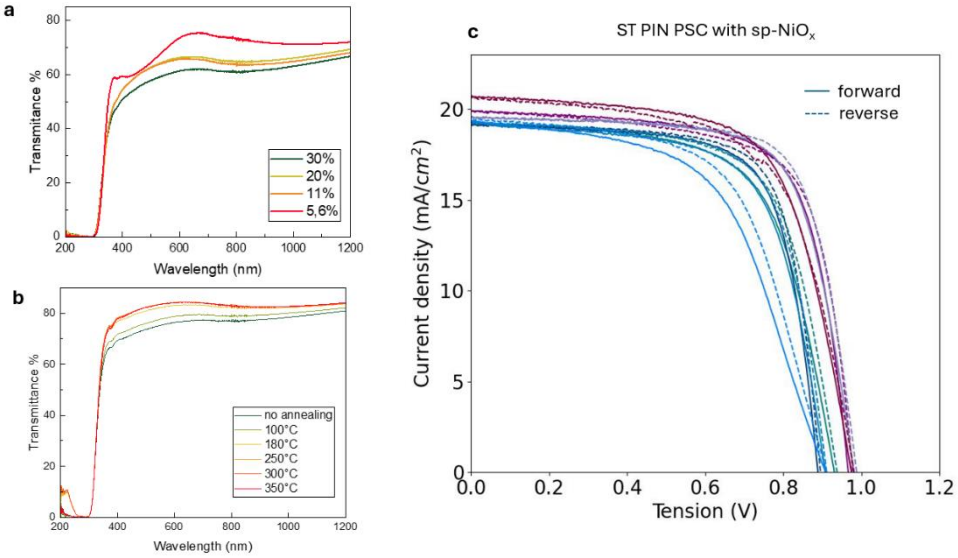

Figure 1: Influence of a) the % of O_2 during the deposition and b) post annealing treatments on the optical properties of sputtered-NiO_x thin films deposited on glass. c) JV curves of semi-transparent PIN perovskite solar cells with sp-NiO_x as HTL.

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2. Tutundzic, M. *et al., Sol. RRL* 2300862 (2023) doi: 10.1002/solr.202300862.
3. Zhang, X. *et al.*, *ACS Energy Lett.* **8**, 2532–2542 (2023).doi: 10.1021/acsenergylett.3c00697