# Selective deposition of nickel oxide for silicon-perovskite tandem solar cells by ALD and PECVD

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Nickel oxide ($NiO_x$) is one of the most promising materials for Hole Transport Layer (HTL) for perovskite-based solar cells [1]. In perovskite-silicon tandem architectures, the recombination junction between the silicon bottom cell and the perovskite top cell is formed by an Indium Tin Oxide (ITO) layer covered by said $NiO_x$. Due to the high cost of Indium, some studies have been focusing on ITO substitution, and carrier recombination through a silicon tunnel junction [2]. However, these studies highlighted the relatively poor electrical properties of the $NiO_x$-Si interface, preventing the carrier recombination, reducing the tandem cell efficiency. This issue could be settled by doping the $NiO_x$, but would lead to a decrease in its transparency [3]. To overcome this problem, the decorrelation of the electrical and optical demands on the HTL could be a solution. By combining the localized deposition of doped $NiO_x$ with a surrounding deposition of a transparent resistive material, the HTL created would let both the carriers and photons go to the recombination junction and the silicon bottom cell. A known method for selective deposition by Atomic Layer Deposition (ALD) is through the use of small molecules, adsorbed at the substrate surface, to inhibit the deposition locally, as shown Figure 1 [4] [5]. Moreover, metal oxides show affinity differences regarding $CO_2$ adsorption, shown in Figure 2 [6]. By combining these two facts and using a highly surface-dependent nickel precursor during the ALD process (the $Ni(amd)_2$), $NiO_x$ could be deposited selectively. Using this innovative method, 90% selectivity has been obtained after 100 ALD cycles between ZnO and $SiO_2$. Complementary analysis, such as wettability and surface acidity measurements, have been performed to better understand the metal oxide surface behavior and to increase the selectivity of the process. The absence of SAM's or an etching step makes this method suitable for perovskite-based solar cells and a first proof of concept has been realized to demonstrate the feasibility and the benefits of local deposition for tandem solar cells.

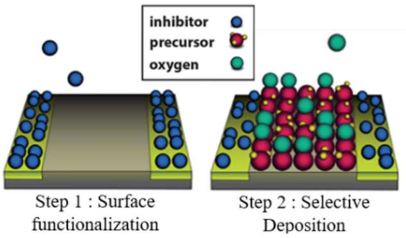


*Figure 1 : Selective deposition through local surface inhibition (taken from [4])*

| Oxide | $CO_2$ uptake (molecules/$m^2$) |
|---|---|
| $TiO_2$ | $1.4\times10^{17}$ |
| $Fe_2O_3$ | $5.0\times10^{17}$ |
| $Fe_3O_4$ | $6.5\times10^{17}$ |
| CaO | $30.2\times10^{17}$ |
| $Fe_2O_3$/CaO | $6.6\times10^{17}$ |
| Si $O_2$ | 0 |

*Figure 2 : Adsorbed $CO_2$ molecules for different oxides (taken from [6])*

References:

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