

## Vanadium-doped Nickel Oxide as an Effective Hole Transport Layer for Inverted Perovskite Solar Cells

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Metal oxide-based electrodes play a crucial role in perovskite solar cell application. Here, we display that size tuned Nickel oxide (NiO) electrode with better electrical conductivity and hole extraction. Also, vanadium doped nickel oxide exhibits a lower crystalline size compared to pristine nickel oxide, which maintains the reduction of surface roughness. Therefore, these results indicating that the vanadium is an excellent dopant for NiO. V:NiO were synthesized by the reduction of nickel (II) acetylacetonate and vanadium pentoxide with the borane-trimethylamine complex in a mixture of deylamine. Pristine and Vanadium doped NiO films were deposited under room temperature on cleaned ITO glass substrates by spin coating. The photovoltaic property of fabricated inverted perovskite solar cells shows that  $V^{5+}$  doping could effectively enhance the conductivity of the NiO film. The improvement of electrical conductivity can promote better charge transport and reduction of interfacial charge accumulation.