Incorporation of Co^{2+} , Cu^{2+} , and Zn^{2+} ions into nickel oxide thin films and their enhanced electrochemical and electrochromic performances

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Nickel oxide (NiO) thin films incorporating cobalt (Co), copper (Cu), and zinc (Zn) dopants were prepared using a simple and cost-effective sol-gel spin-coating method. Changing the dopant allowed the color of the NiO thin films to be tuned. Cracking on the surface of the NiO thin films was effectively reduced by the incorporation of dopants. The undoped NiO and Co-doped NiO thin films had a relatively porous nanoparticle structure, whereas the Cu- and Zn-doped NiO thin films had a more compact nanoparticle structure. Compared with the undoped NiO sample, the cyclic voltammetry (CV) curves of the doped NiO thin films exhibited higher integrated current densities. In particular, the CV curves of the Co-doped NiO thin film showed no symmetric distortion as the scan rate increased, indicating a highly reversible redox process. At a scan rate of 5 mV/s, the calculated areal specific capacitance was 19.7 mF/cm², and it showed excellent cycling stability at high scan rate (~88% retention at 100 mV/s after 2000 cycles). The color of the Co-doped NiO thin film changed from pale pink (bleached state) to brown (colored state). Co doping demonstrated great potential for improving the electrochemical and electrochromic performance of NiO thin film, while also offering long-term stability and enhanced optical modulation.

Keywords: NiO, Thin film, Electrochemical stability, Electrochromic performance

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