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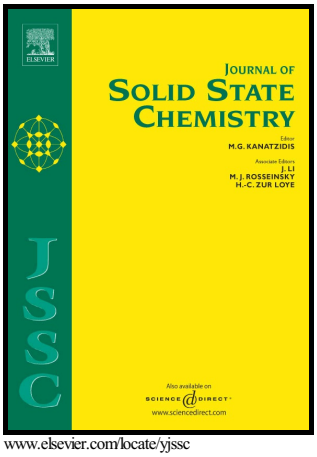

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Abstract

The Cu^{2+} and Zn^{2+} co-doped CeO_2-based solid solutions were synthesized via hydrothermal method. The microstructure and the spectra features of the solid solutions were characterized systematically. The XRD results showed that the dopants were incorporated into the CeO_2 lattice to form $Ce_{1-x}Cu_{0.5x}Zn_{0.5x}O_2$ solid solutions when x was lower than 0.14. The cell parameters and the crystalline size decreased linearly, and the lattice strain gradually increased with increasing the doping level. The TEM patterns showed that the particle size in the solid solution was lower than 10 nm which is in accordance with the XRD results. The ICP analysis indicated that the real doped content in the solid solution was close to the nominal proportion. XPS proved that the Ce^{3+} component was increased by doping. The Raman and PL spectra indicated that the lattice distortion and the oxygen vacancies also increased following the same trend. At the same time, the synergistic effects of two ions co-doped solid solutions were studied by comparing them with that of single ions doped samples. The catalysis effects of Cu^{2+} and Zn^{2+} co-doped CeO_2-based solid solutions on the hydrogen storage electrochemical and kinetic properties of Mg_2Ni alloys were detected. The electrochemistry properties of the Mg_2Ni-Ni-5wt% $Ce_{1-x}Cu_{0.5x}Zn_{0.5x}O_2$ composites indicated that the doped catalysts could provide better optimizations to improve the maximum discharge capacities and the discharge potentials. On the other hand, the charge transfer abilities on the surface and diffusion rate of H atoms in the bulk of alloys also got improved. The DSC measurements showed that the hydrogen desorption activation of the hydrogenated composites with $Ce_{0.88}Cu_{0.06}Zn_{0.06}O_2$ solid solutions decreased to 77.03 $kJ \cdot mol^{-1}$, while that of the composites with pure CeO_2 was 97.62 $kJ \cdot mol^{-1}$. The catalysis effect was enhanced by the doped content increase that means that the catalysis mechanism had close links to the oxygen vacancy concentration and the lattice defects in the solid solutions. On the other hand, the doped Cu^{2+} and Zn^{2+} ions could also play an important role in the catalytic process.

Graphical abstract

The corresponding HRTEM image as is shown in the figure reveals the well defined fringes with interplanar spacing of 0.31 nm corresponding to the (111) planes of CeO_2. The SEAD pattern presents several concentric diffraction circles, which suggests the existence of polycrystalline species. These diffraction rings can be indexed to the (111), (200), (220), (311), (400), (422) and (311) of CeO_2 nanoparicles.