

Uniform and Porous $\text{Ce}_{1-x}\text{Zn}_x\text{O}_{2-\delta}$ Solid Solution Nanodisks:

Preparation and Their CO Oxidation Activity

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Supplementary Information

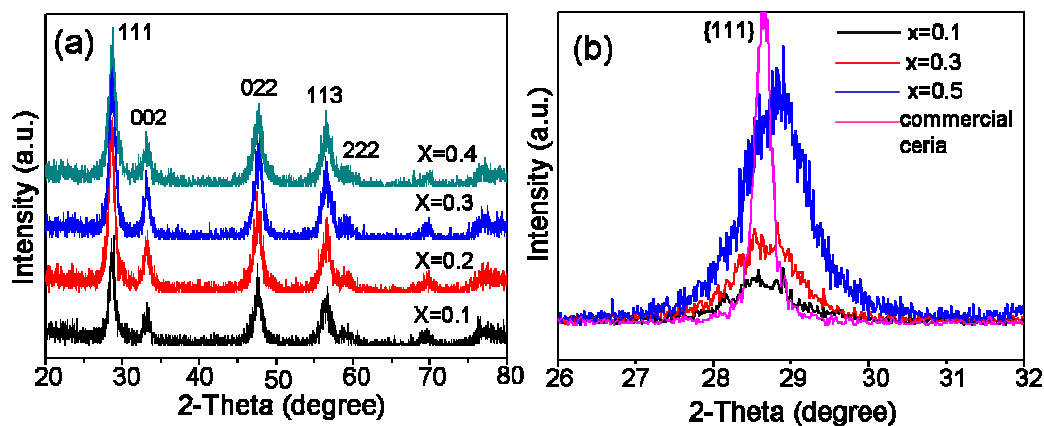


Figure S1. (a) The XRD patterns of Ce-Zn_x precursor calcined in air at 600 °C for 3 h, (b) fine scan of the (111) peaks.

By comparing with X-ray spectra from Ce-Zn_x nanodisks and commercial ceria (AR grade), peak shift towards wider angles and peak widening in Ce-Zn_x nanodisks was observed, indicating that the lattice parameter is decreased. According to the references,¹⁻³ we obtain the lattice parameter of these Ce-Zn_x based on the XRD results. Comparing with commercial ceria, the lattice parameter decreases from 0.5410 nm (commercial ceria) to 0.5394 nm for Ce-Zn_x . The lattice distortion of Ce-Zn_x was caused by the introduction of the oxygen vacancies via doping with Zn^{2+} and the accompanying Ce^{3+} ions.¹⁻³ The result is consistent with the XPS analysis.

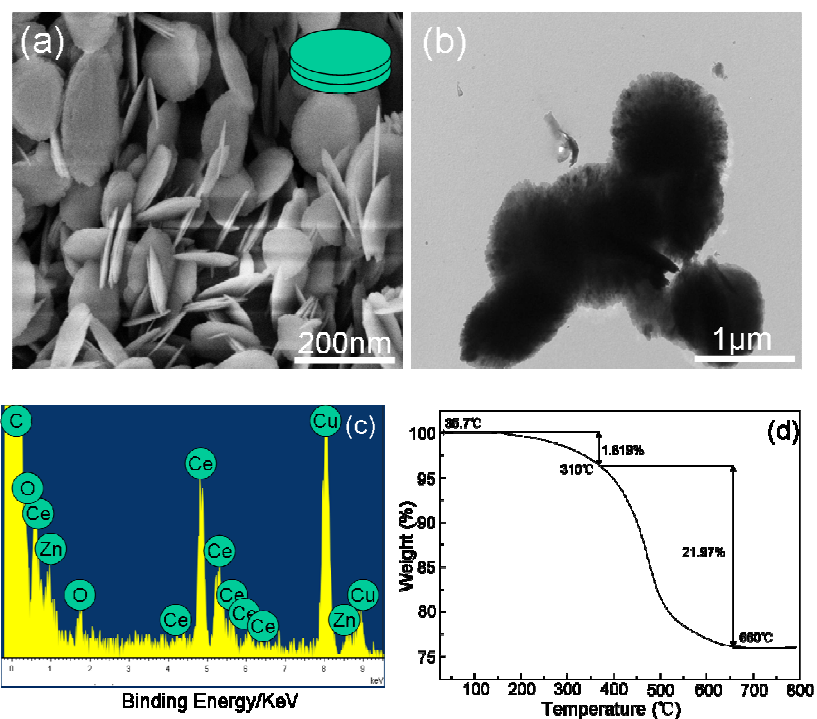


Figure S2. (a) SEM image and (b) TEM image, (c) EDS analysis, (d) TG analysis of the $\text{Ce-Zn}_{0.3}$ precursor prepared at 160 °C for 24 h.

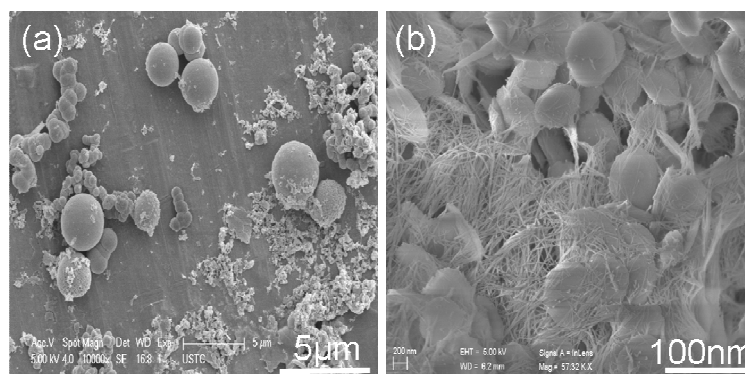


Figure S3. SEM images of the as-prepared $\text{Ce-Zn}_{0.3}$ precursor at different temperature. (a) 120 °C, 8 h; (b) 160 °C, 8 h.

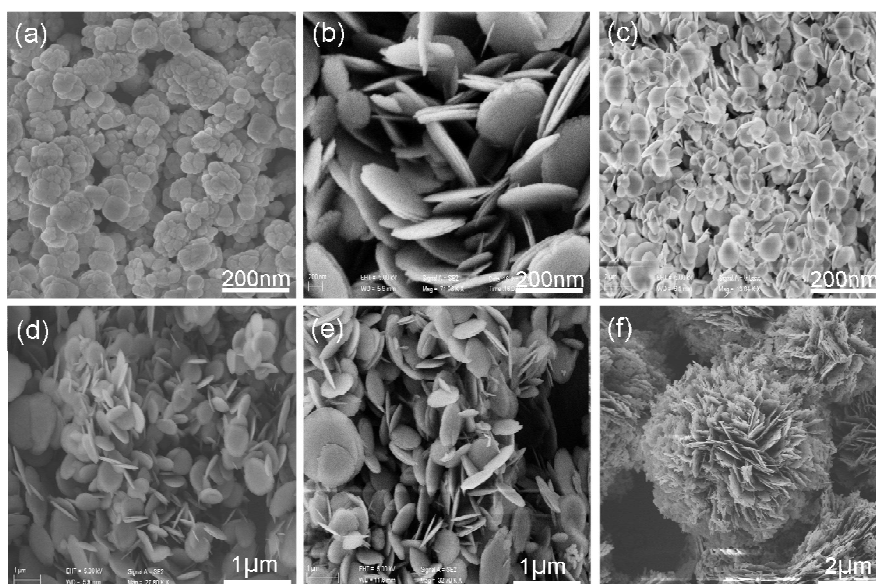


Figure S4. SEM images of the Ce-Zn_x precursors prepared at 160 °C for 24 h with different molar ratios of Ce^{3+} to Zn^{2+} . (a) $x = 0$; (b) $x = 0.1$; (c) $x = 0.2$; (d) $x = 0.3$; (e) $x = 0.4$; (f) $x = 1.0$.

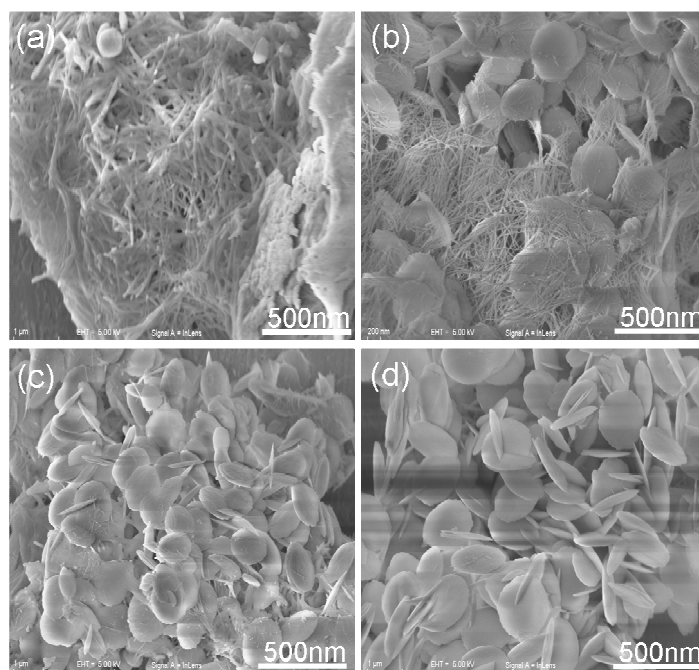
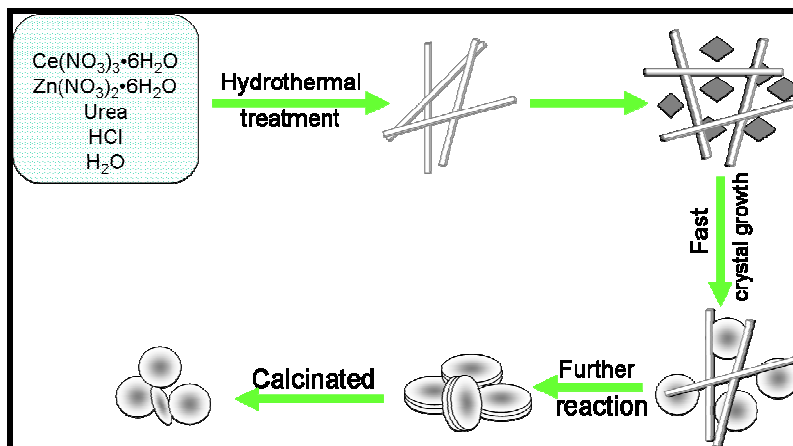
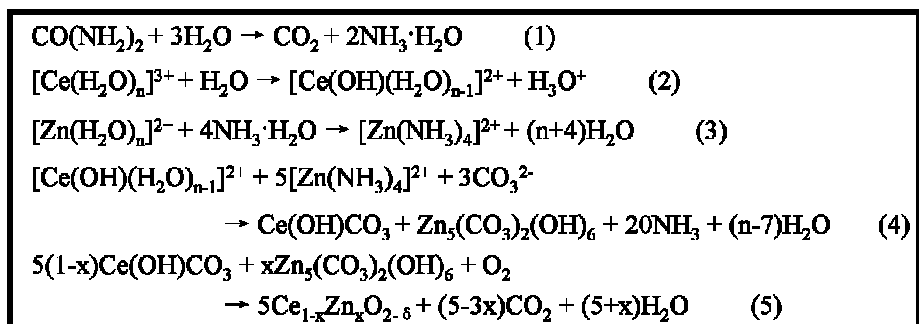


Figure S5. SEM images of the $\text{Ce-Zn}_{0.3}$ precursor prepared at 160 °C for different reaction time. (a) 4 h, (b) 8 h, (c) 16 h, and (d) 24 h.



Scheme S1. Schematic illustration of the formation process of **Ce-Zn_x** nanodisks may be summarized by the above reactions.

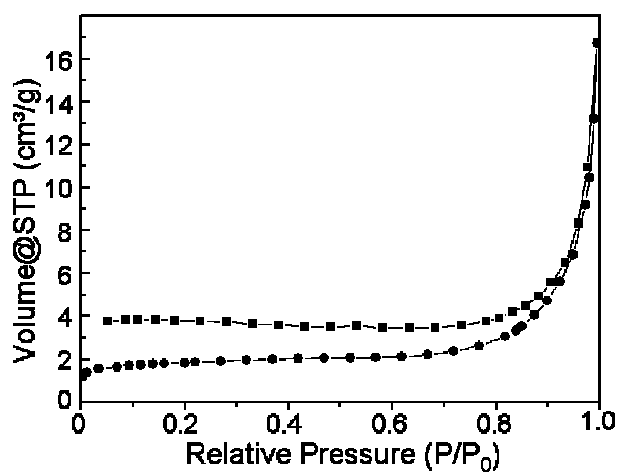


Figure S6. N₂ adsorption and desorption isotherms of the porous **Ce-Zn_{0.3}** nanodisks.

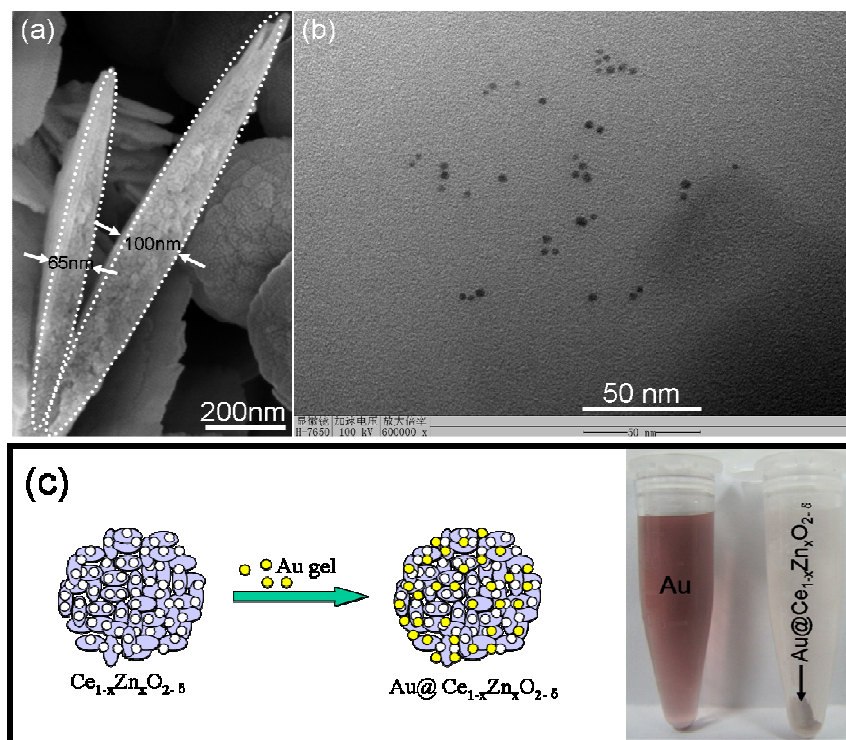


Figure S7. (a) SEM image of cross-section of Au@Ce_{1-x}Zn_xO_{2-δ} (x = 0.3), (b) TEM image of Au nanoparticles, (c)

Ce-Zn_{0.3} nanodisks adsorbed Au gel at the room temperature for 2 h.

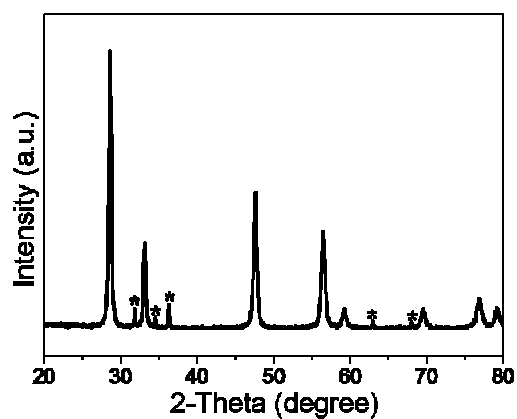


Figure S8. XRD pattern of Ce-Zn_{0.6}. The phase of ZnO was indicated with *.

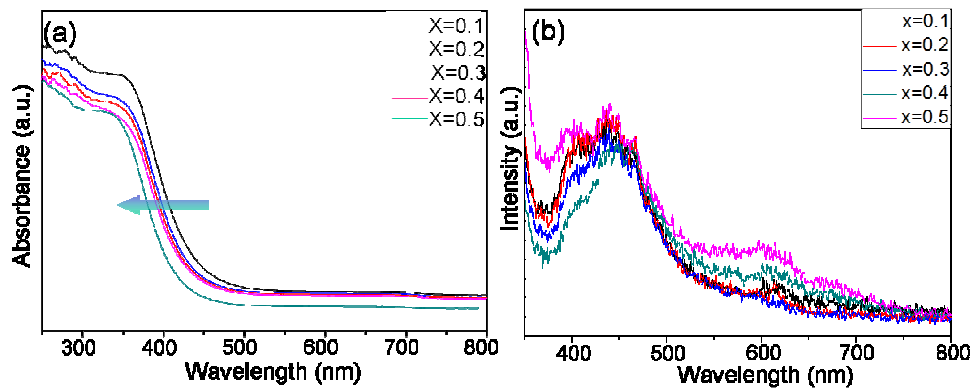


Figure S9. (a) UV-vis and (b) PL spectra of Ce-ZnO_3 solid solutions.

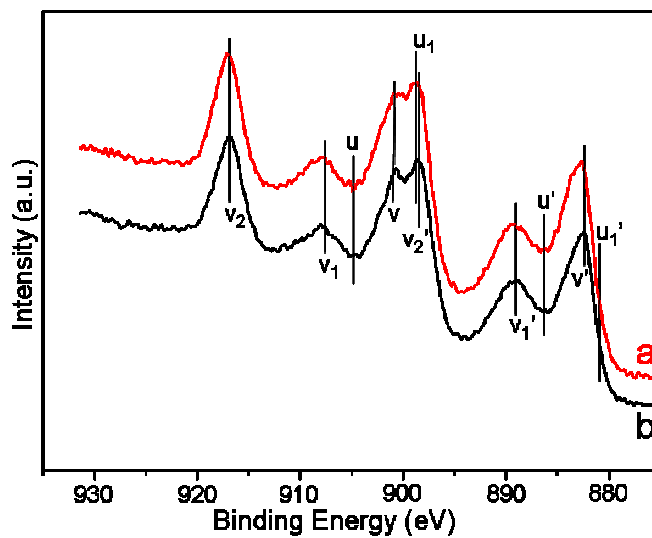


Figure S10. Ce3d XPS spectra from (a) ceria, (b) Ce-ZnO_3 nanodisks prepared by precipitation and treated at the same temperature.

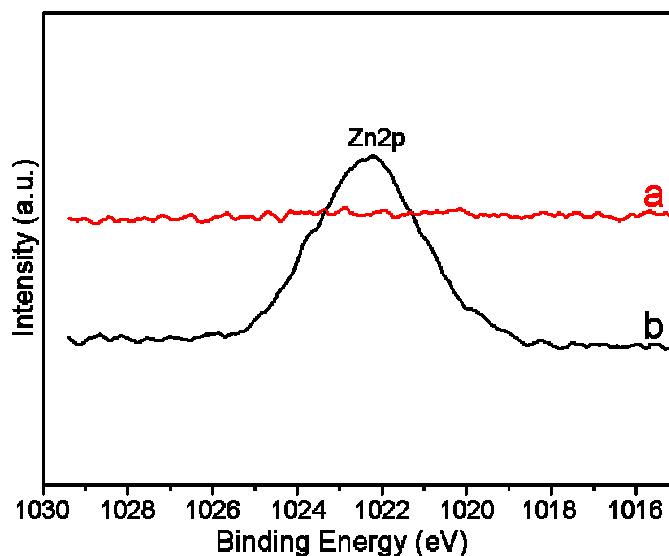


Figure S11. Zn2p XPS spectra from (a) ceria, (b) $\text{Ce-Zn}_{0.3}$ nanodisks prepared by precipitation and treated at the same temperature.

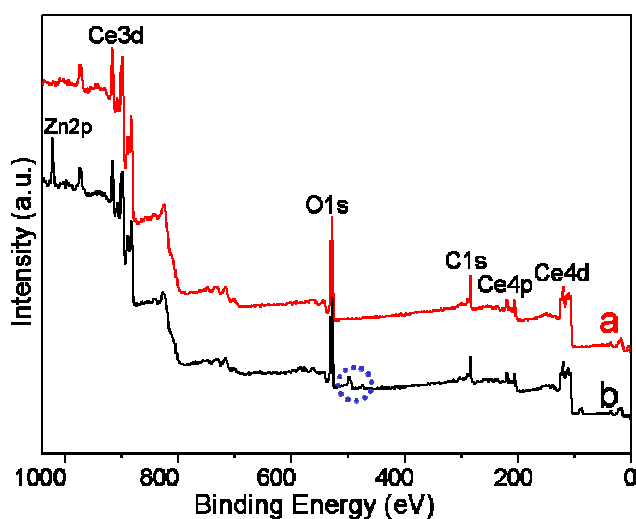


Figure S12. XPS full spectra of (a) ceria and (b) $\text{Ce-Zn}_{0.3}$ nanodisks.

Figure S9 shows that the X-ray photoelectron spectra (XPS) obtained for the materials. The spectrum that obtained from traditional ceria and $\text{Ce-Zn}_{0.3}$ prepared by precipitation is also given for comparison. The Ce 3d level has a very complicated structure. Six peaks labeled as v , v_1 , v_2 ($3d_{5/2}$), v' , v_1' , v_2' ($3d_{3/2}$) involving three pairs of spin-orbit doublets can be identified and they are characteristic of $\text{Ce}^{4+}3d$ final states.^{4, 6} By comparing with the conventional ceria nanoparticles,

four peaks due to two pairs of doublets [noted as u , u' , u_1 , u_1'] corresponding to $Ce^{3+}3d$ states can be observed in the $Ce-Zn_{0.3}$ samples. The doublet u_1 and u_1' are characteristic of Ce^{3+} species which lie at 885.7 eV and 904.1 eV, respectively.^{4, 5} The full XPS spectra of ceria and $Ce-Zn_{0.3}$ indicated that there were only cerium, zinc and oxygen element in the samples. The weak C1s peak and blue circle were due to the contamination of the samples.⁴ Through the full spectra analysis, we could exclude the possible influence of other ions which may involve in the samples such as NO^{3-} during the experimental procedure.

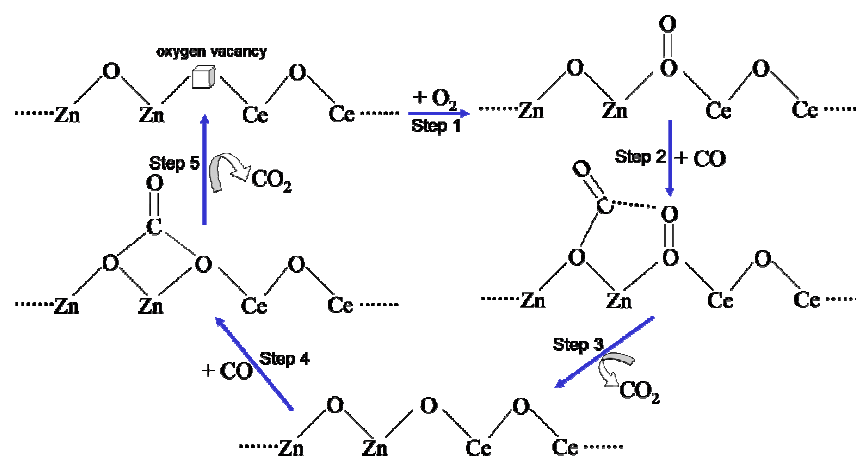


Figure S13. Proposed CO reaction pathways over $Ce-Zn_x$ solid solution.

References:

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