# Supporting Information

## Ultra-stable nanosized $Ce_{0.9}Fe_{0.1}O_2$ solid solution with an excellent catalytic performance towards $CH_4$ oxidation

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**Sample synthesis of S-$Ce_{0.9}Fe_{0.1}O_2$:**

A combination of solutions of 0.225M $Ce(NO_3)_3{\cdot}6H_2O$ and 0.225M $Fe(NO_3)_3{\cdot}9H_2O$ with the molar ration of Ce:Fe=9:1 were fully mixed for 2h. A solution of citric acid with 1.2 times of molar amounts to the premixed nitrate solutions of cerium and ion was added. After stirring at 80 $^oC$ for 12 hours, the obtained gel was dried at 100 $^oC$ for 12 hours. The as obtained powder was then calcined under ambient air at 600 $^oC$ and 700$^oC$ for 4 hours respectively. These sample were named as S600-$Ce_{0.9}Fe_{0.1}O_2$ and S700-$Ce_{0.9}Fe_{0.1}O_2$.

**Sample characterization**

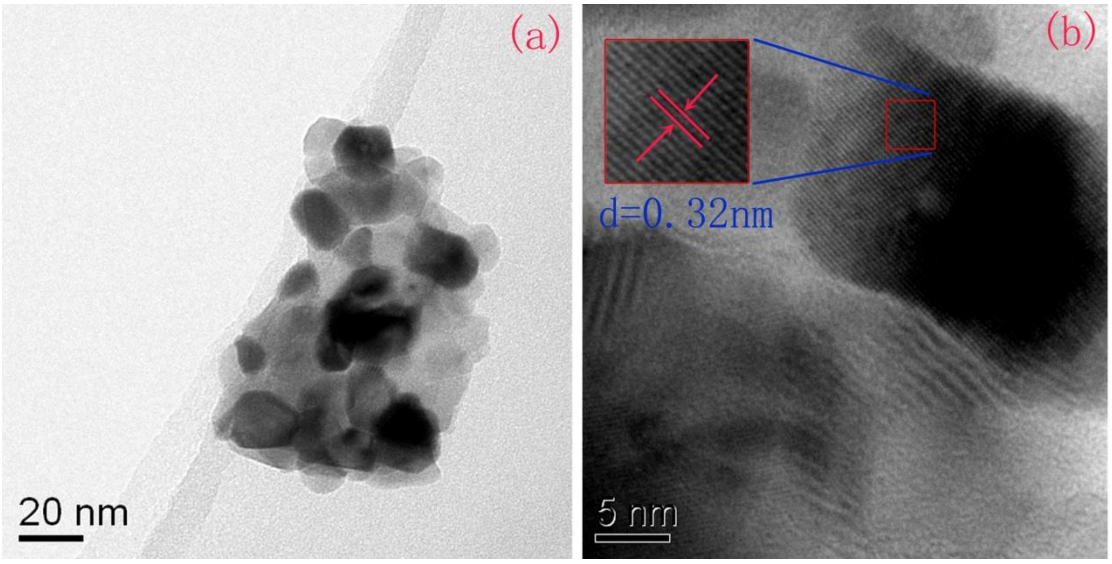


**Fig. S1** TEM images of S-$Ce_{0.9}Fe_{0.1}O_2$

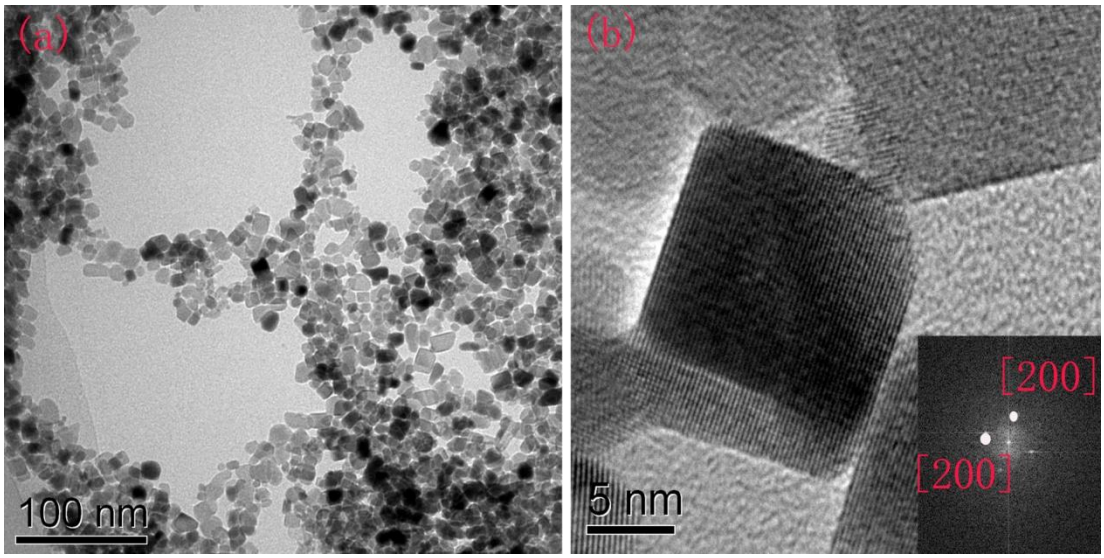


**Fig. S2** TEM images of H-$CeO_2$

As indicated in Fig. S2b, the spacing of the fringes parallel to the top and bottom of the nanocube is 0.27 nm, which can be attributed to the (200) facet. In addition, the angle between (200) planes is 90$^o$ on the basis of fast Fourier transform (FFT). Therefore, each nanocube exposed six equivalent (200) facets.

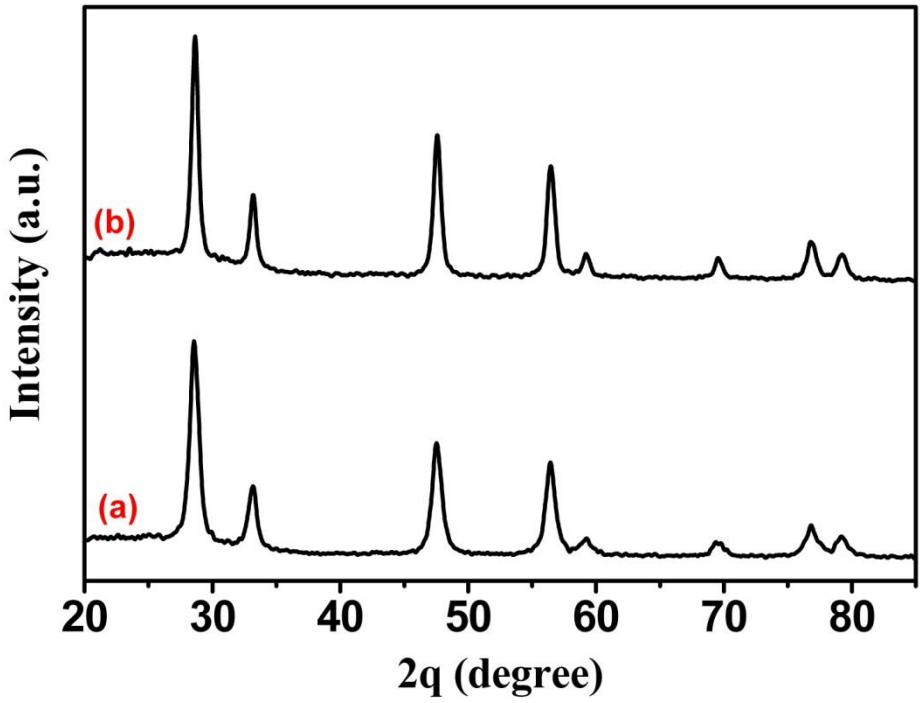


**Fig. S3** XRD images of (a) S600-$Ce_{0.9}Fe_{0.1}O_2$ and (b) S700-$Ce_{0.9}Fe_{0.1}O_2$.

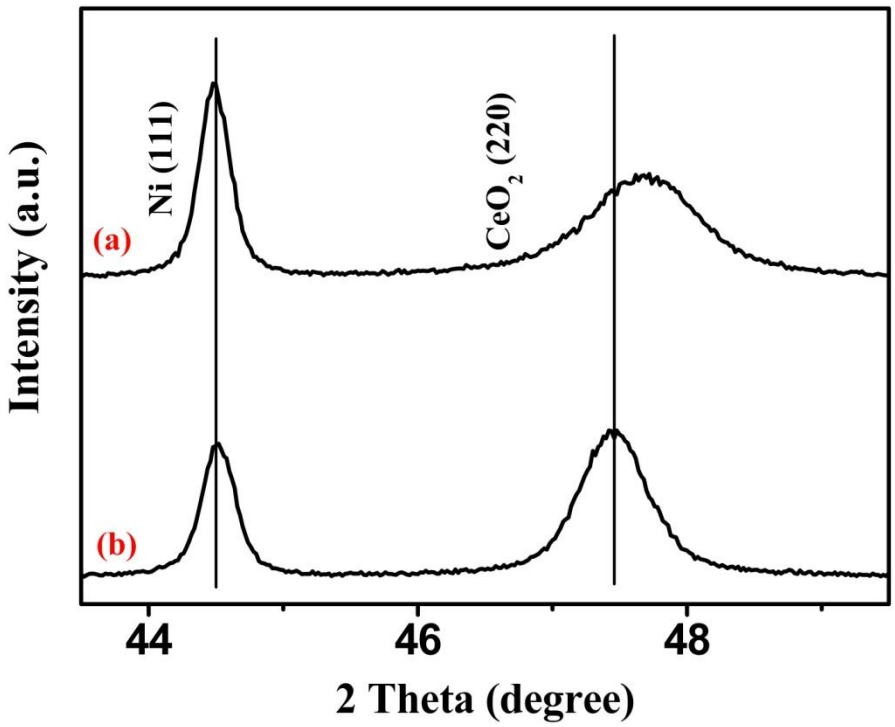


Fig. S4 An amplification of the XRD patterns of (a) H-$Ce_{0.9}Fe_{0.1}O_2$ (b) H-$CO_2$ between 43-50 degree. Ni was selected as an internal standard for peak position determinations.

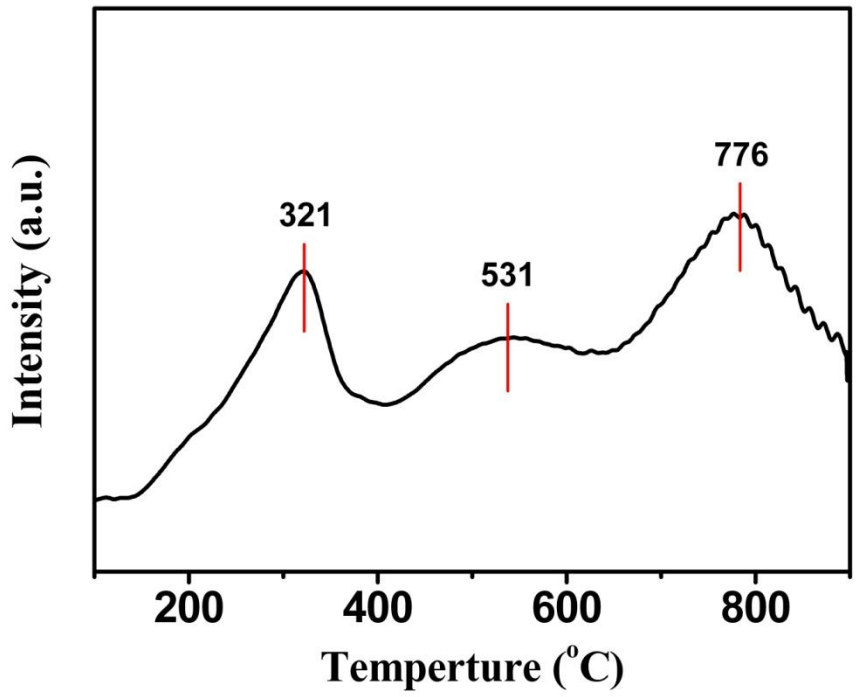


**Fig. S5** $H_2$-TPR data for S600-$Ce_{0.9}Fe_{0.1}O_2$.