Electronic Supplementary Material (ESI) for Nanoscale.


# Supporting Information

## Fabrication of Hollow $ZrO_2$ Nanoreactors Encapsulating Au-$Fe_2O_3$ Dumbbell Nanoparticles for CO Oxidation

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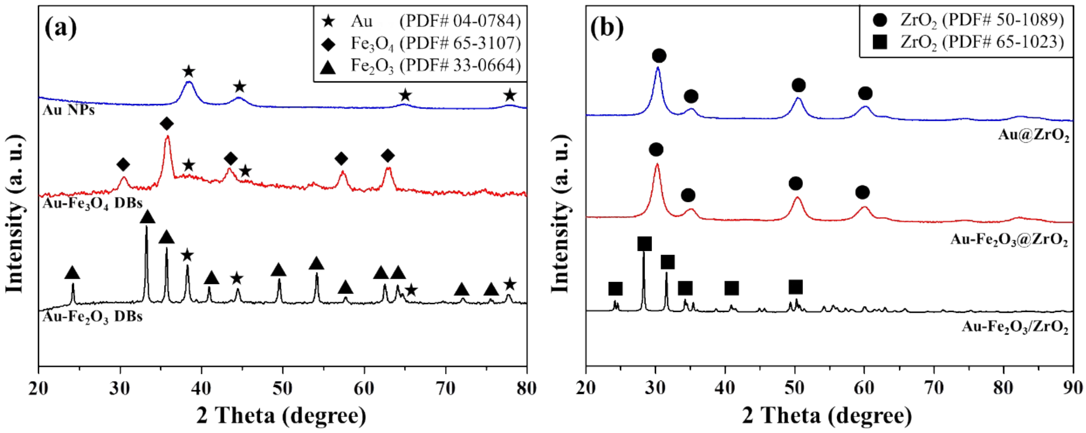


**Fig. S1** XRD diffraction patterns of (a) Au NPs, Au-$Fe_3O_4$ DBs, and Au-$Fe_2O_3$ DBs obtained by calcination of Au-$Fe_3O_4$ at 700 °C; (b) Au@$ZrO_2$, Au-$Fe_2O_3$@$ZrO_2$ and Au-$Fe_2O_3$/$ZrO_2$ catalysts.

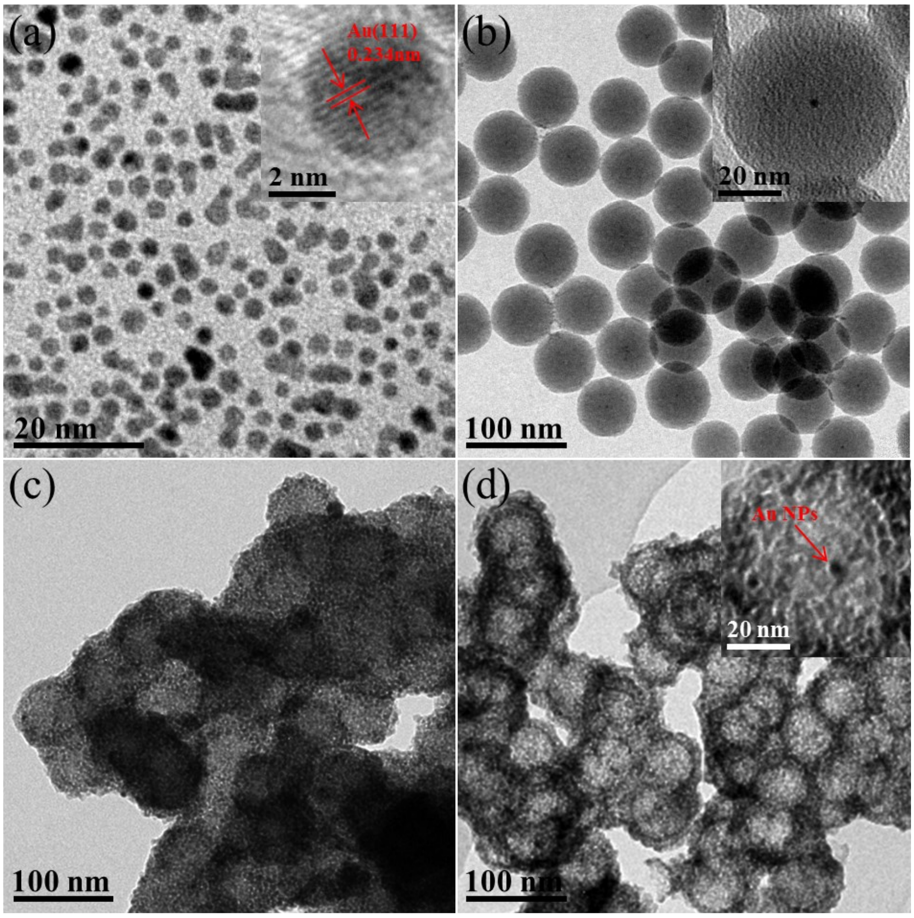


**Fig. S2** TEM images show (a) Au NPs, (b) Au@$SiO_2$, (c) Au@$SiO_2$@$ZrO_2$, (d) Au@$ZrO_2$ yolk-shell nanoreactors. The insert of (a) show the HRTEM images of Au NPs with scale of 2 nm and TEM images of Au@$SiO_2$ and Au@$ZrO_2$ yolk-shell NPs with scales of 20 nm are shown in the insert of (b) and (d), respectively.

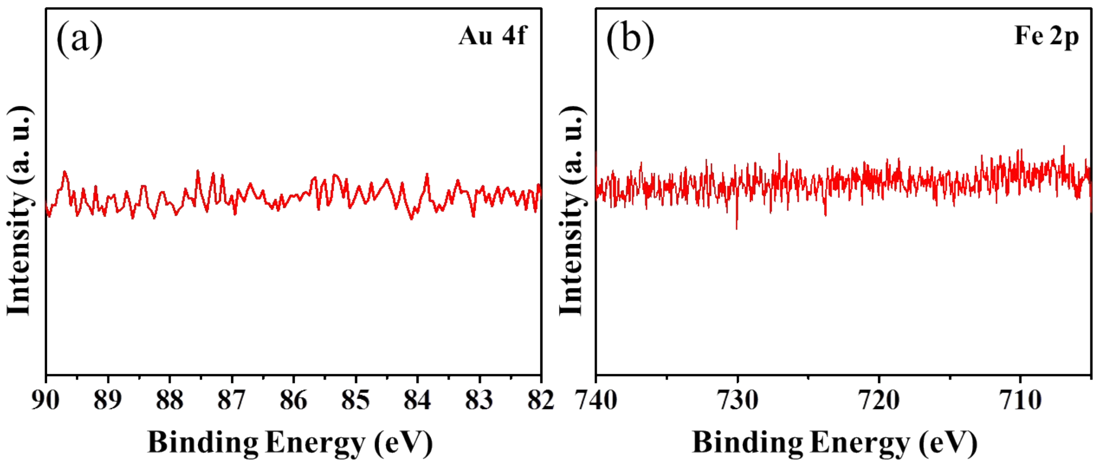


**Fig. S3** (a) Au 4f spectra for Au-$Fe_2O_3$@$ZrO_2$ nanoreactors; (b) Fe 2p spectra for Au-$Fe_2O_3$@$ZrO_2$ nanoreactors.

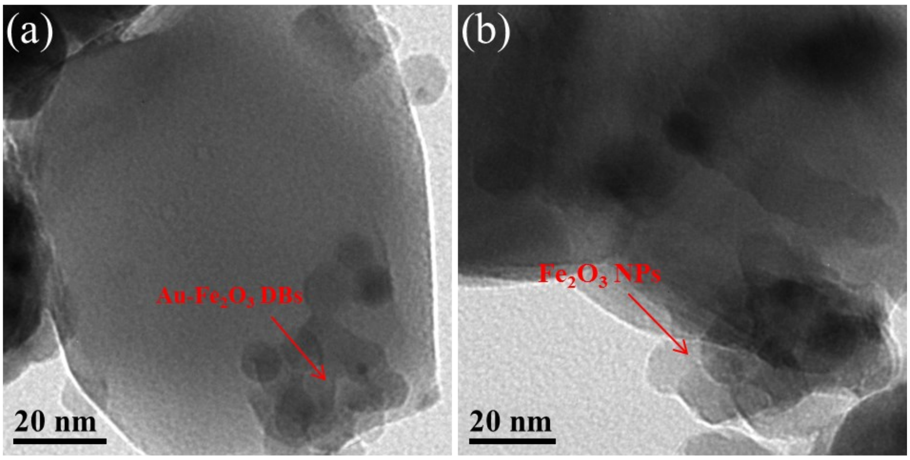


**Fig. S4** TEM images show (a) Au-$Fe_2O_3$/$ZrO_2$ and (b) $Fe_2O_3$/$ZrO_2$ supported catalysts.

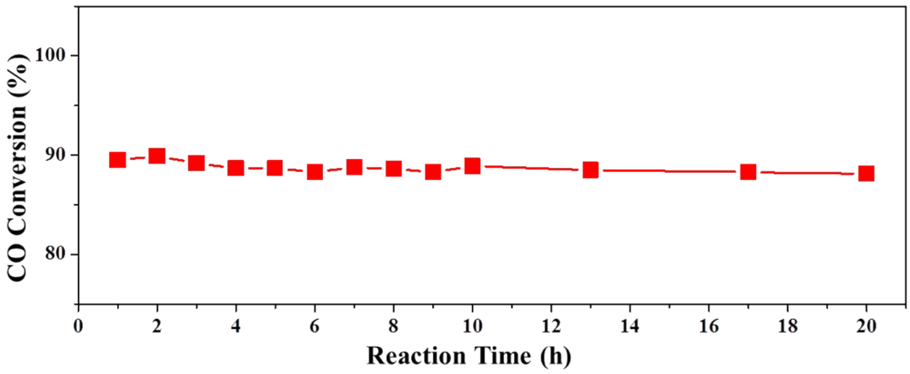


**Fig. S5** Long-term stability of CO oxidation over Au-$Fe_2O_3$@$ZrO_2$ yolk-shell nanoreactors.

**Table S1** Physical properties and catalytic performance of Au catalysts.

| Cat. | Au loading/wt.% | Au d/nm | $T_{50}$/°C | TOF/$h^{-1}$ | Ref. |
|---|---|---|---|---|---|
| Au-$Fe_2O_3$@$ZrO_2$ | 0.1 | 2.5 | ~ 85 | 1099.16 | This work |
| Au/$TiO_2$ | 1.0 | 3.8 | -6 | 334.15 | S1 |
| Au/$Fe_2O_3$ | 3.7 | 2.7 | -16 | 64.17 | S2 |
| Au/$Ni_{0.05}$Al | 3 | 2.4 | 13 | 281.39 | S3 |
| Au/$TiO_2$@$ZrO_2$ | 7.5 | 8 | 60 | 375.18 | S4 |
| Au@$CeO_2$ | 0.93 | 17 | 80 | 1205.5 | S5 |
| Au@$ZrO_2$ | 6.8 | 14 | 150 | 724.15 | S6 |
| Au/ZnO | 3.8 | 1.7 | <-90 | 39.34 | S7 |
| Au/α-$Fe_2O_3$ | 1.86 | 2.3 | <20 | 543.67 | S8 |
| Au-$CeO_2$@$ZrO_2$ | 0.55 | 15 | 200 | 19185.39 | S9 |

TOF ≈ r (CO conversion) • d (Au diameter) [S1]

r (CO conversion) defined as moles of CO converted per mol of total Au per hour at $T_{50}$.

**References**


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