

**Exceptional capability of nanosized CeO<sub>2</sub> materials to “dissolve“ lanthanide oxides established by time-gated excitation and emission spectroscopy**

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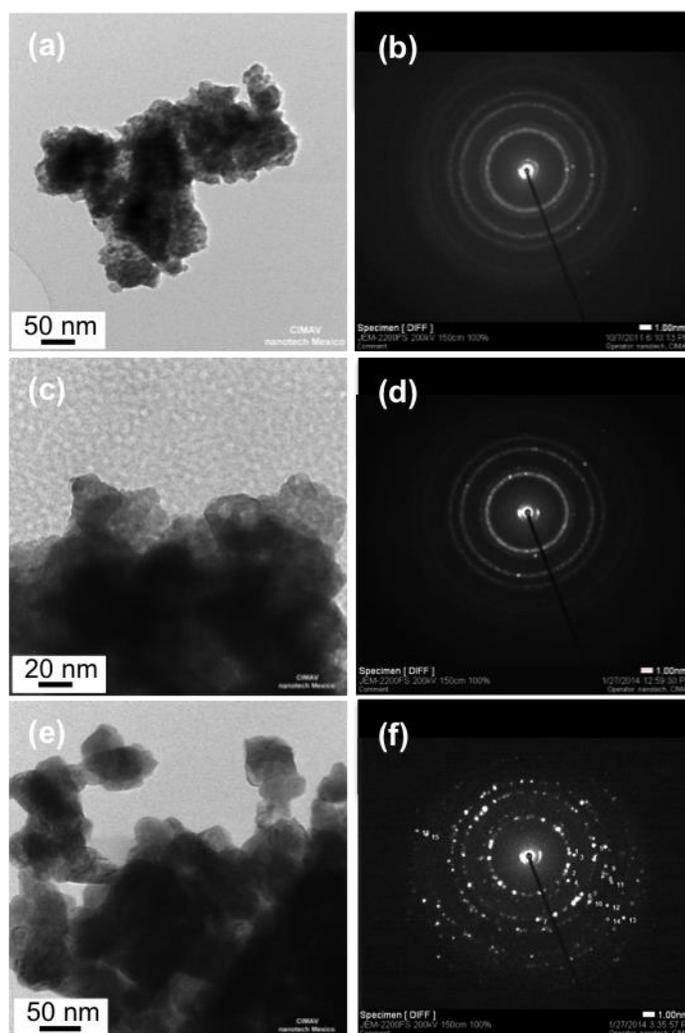
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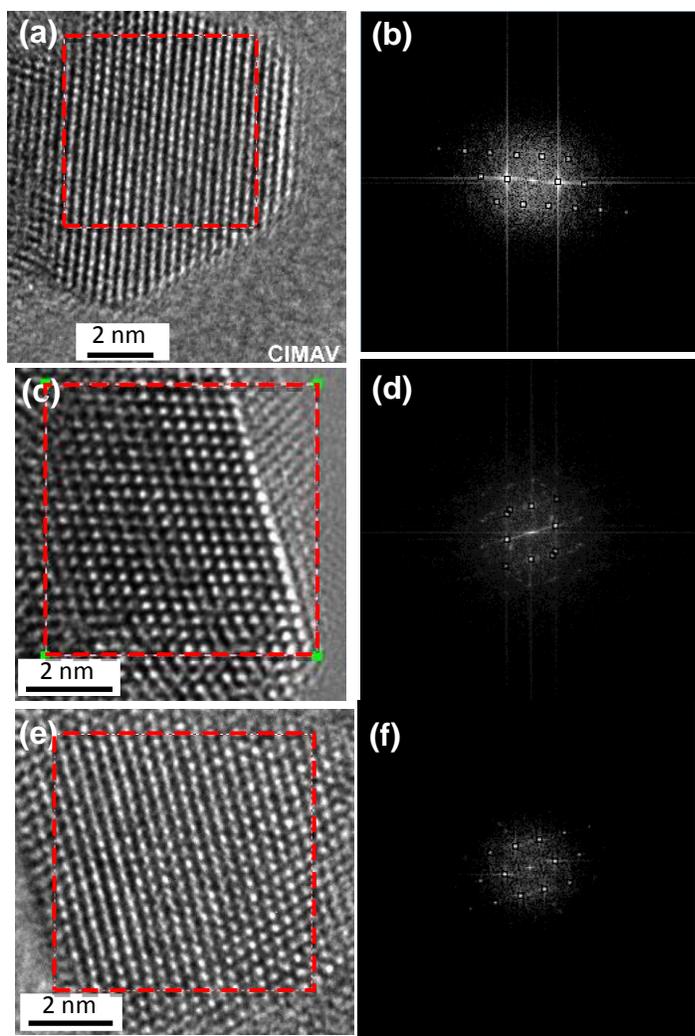
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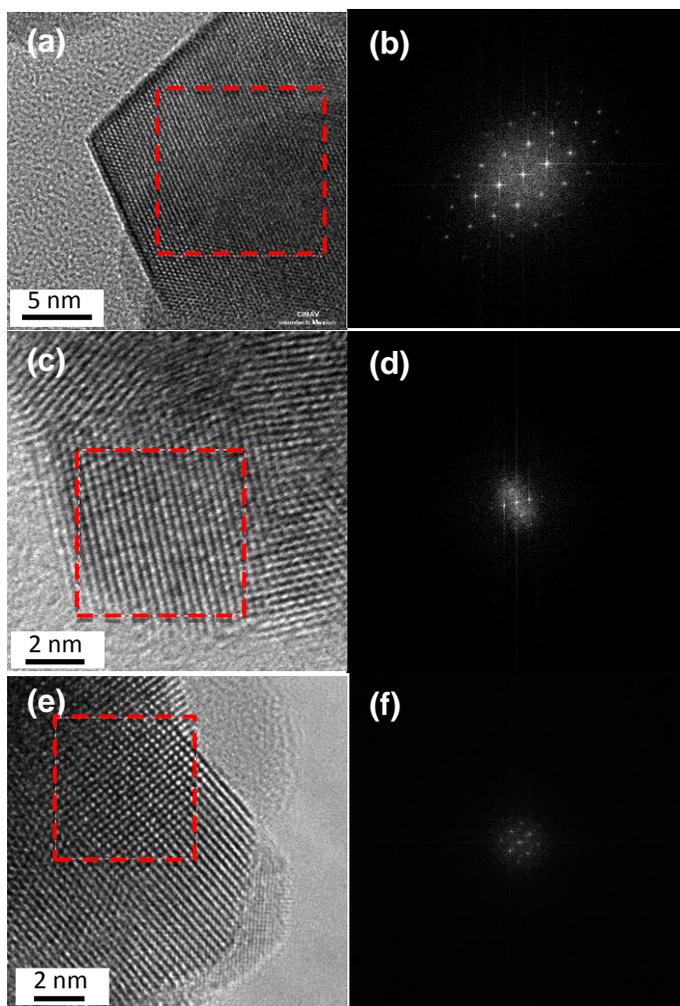
**Supporting Information**



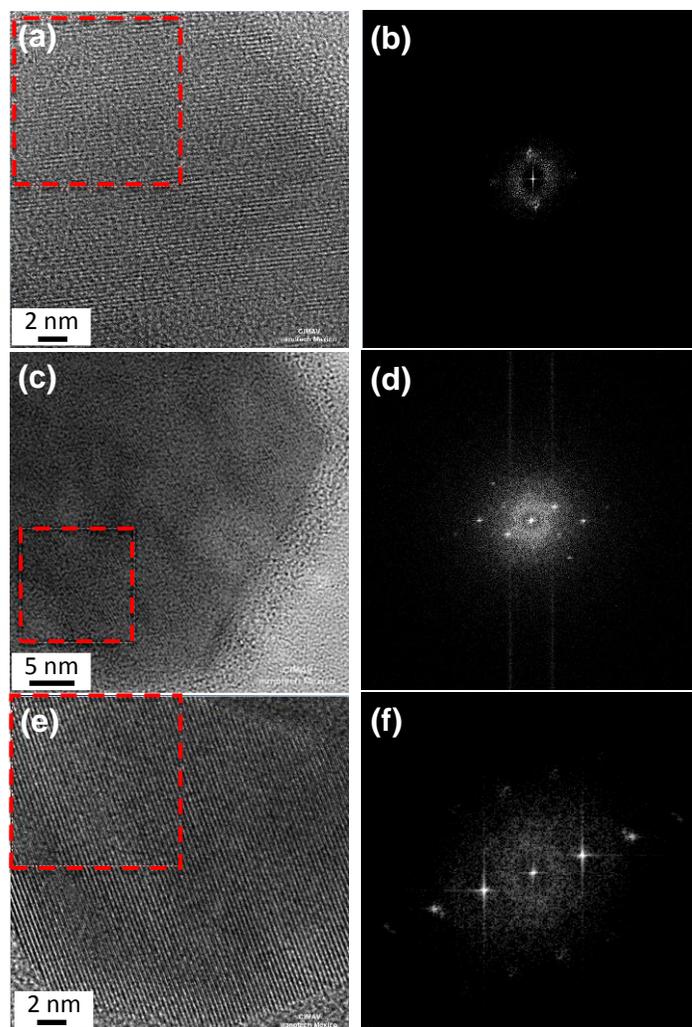
**Figure S1.** HRTEM images and their corresponding SAED pattern. (a) and (b) CZ-750, corresponding d-spacings: 3.03, 2.64, 1.87, 1.58 and 1.06 Å, which may be consistent with hkl 111, 200, 220, 311 and 422 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101, 110, 112, 211 and 312 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (c) and (d) CZE-750, corresponding d-spacings: 3.03, 2.7, 1.9, and 1.6 Å, which may be consistent with hkl 111, 200, 220, and 311 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101, 002, 112 and 103 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (e) and (f) CZE-1000, corresponding d-spacings: 3.04, 2.69, 2.64, 1.86, 1.6, 1.58, 1.32, 1.21, 1.17, and 1.06 Å, which may be consistent with hkl 111, 200, 200, 220, 311, 311, 400, 331, 420, and 422 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101, 002, 110, 200, 103, 211, 220, 213, 310 and 312 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436.



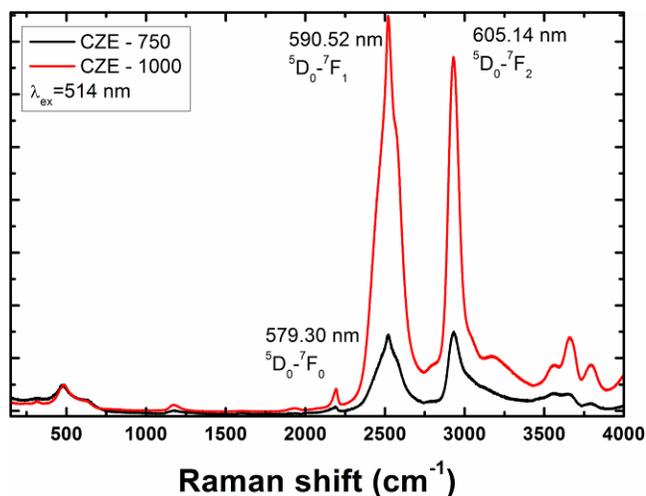
**Figure S2.** HRTEM images of CZ-750 and the corresponding FFT analysis of the area indicated by the red square. (a) and (b) corresponding d-spacings: 3.12, 2.7, 1.91, 1.56 and 1.07 Å, consistent with hkl 111, 200, 220, 222 and 422 of cubic CeO<sub>2</sub>, card number 81-0792 (2002 JCPDS); (c) and (d) corresponding d-spacings: 3.14, 2.6 and 1.9 Å, consistent with hkl 111, 200 and 220 of of cubic CeO<sub>2</sub>, card number 81-0792 (2002 JCPDS); (e) and (f) corresponding d-spacings: 3.05, 2.69, 1.86, 1.6, 1.55, and 1.1 Å, which may be consistent with hkl 111, 200, 220, 311, 222 and 422 of cubic Ce<sub>0.6</sub>Zr<sub>0.4</sub>O<sub>2</sub>, card number 00-038-1439; or with hkl 101, 002, 200, 103, 202, and 204 of tetragonal Ce<sub>0.6</sub>Zr<sub>0.4</sub>O<sub>2</sub> (centrosymmetric), card number 00-038-1436.



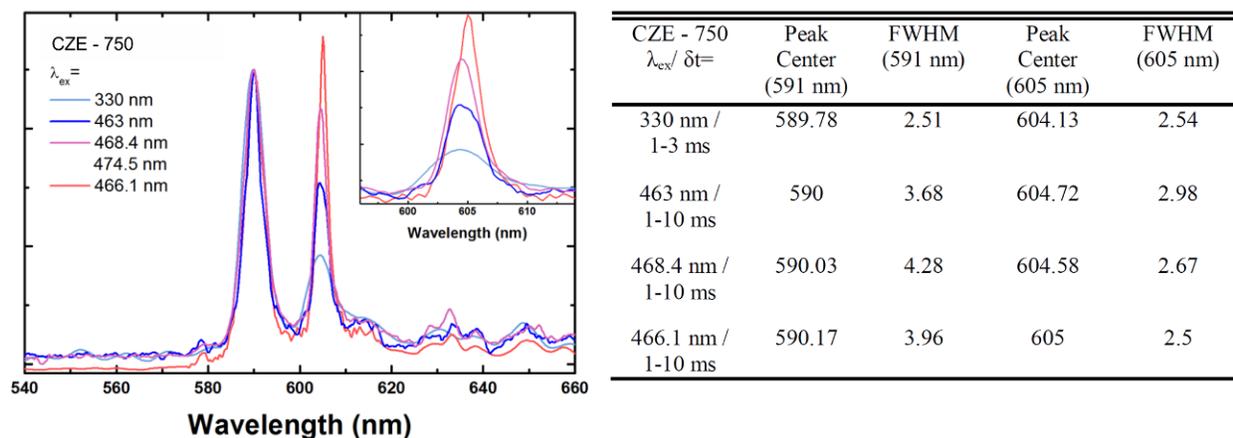
**Figure S3.** HRTEM images of CZE-750 and the corresponding FFT analysis of the area indicated by the red square. (a) and (b) corresponding d-spacings: 3.05, 2.6, 1.87, 1.54 and 1.06 Å, consistent with hkl 111, 200, 220, 222 and 422 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101, 110, 112, 202 and 312 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (c) and (d) corresponding d-spacings: 3.065 and 1.53 Å, consistent with hkl 111 and 222 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101 and 202 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (e) and (f) corresponding d-spacings: 3.03 Å, which may be consistent with hkl 111 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436.



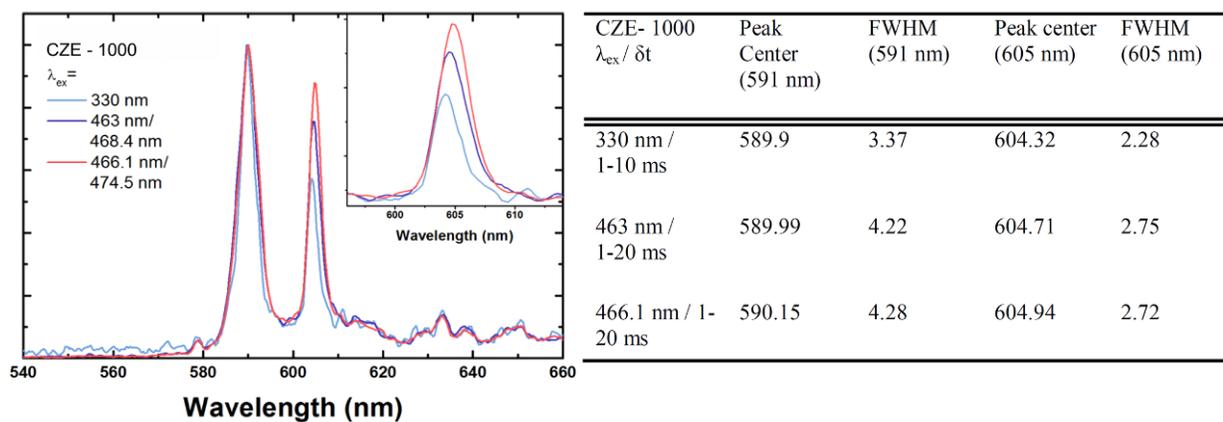
**Figure S4.** HRTEM images of CZE-1000 and the corresponding FFT analysis of the area indicated by the red square. (a) and (b) corresponding d-spacings: 3.05 Å, consistent with hkl 111 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (c) and (d) corresponding d-spacings: 3.05 and 1.58 Å, consistent with hkl 111 and 311 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101 and 211 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436; (e) and (f) corresponding d-spacings: 3.04 and 1.52 Å, which may be consistent with hkl 111 and 222 of cubic  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$ , card number 00-038-1439; or with hkl 101 and 202 of tetragonal  $\text{Ce}_{0.6}\text{Zr}_{0.4}\text{O}_2$  (centrosymmetric), card number 00-038-1436.



**Figure S5.** Raman spectra of 10%  $\text{Eu}^{3+}$  -  $\text{CeO}_2$  -  $\text{ZrO}_2$  which show besides the phonon modes (below  $800\text{ cm}^{-1}$ ), the luminescence transitions of  $\text{Eu}^{3+}$  ( $2000$  to  $4000\text{ cm}^{-1}$ ). The peak values were obtained following  $\text{cm}^{-1}$  to nm conversion (excitation wavelength is  $514\text{ nm}$ ).



**Figure S6.** Luminescence spectra of 10%  $\text{Eu}^{3+}$  -  $\text{CeO}_2$  -  $\text{ZrO}_2$  -750 normalized at  $590\text{ nm}$  peak intensity. **Table S1** summarizes the peak values and widths of emission lines illustrated in **Figure S6**.



**Figure S7.** Luminescence spectra of 10%Eu<sup>3+</sup> - CeO<sub>2</sub> -ZrO<sub>2</sub> -1000 normalized at 590 nm peak intensity. **Table S2** summarizes the peak values and widths of emission lines illustrated in **Figure S7**.