Supplementary Information

Morphology-Dependent Fluorescence of Europium-Doped Cerium Oxide Nanomaterials

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Equation S1. Working Definition of theoretical Eu^{3+} doping percentage.

The theoretical Eu^{3+} concentration with regard to atomic percentage within each material ranges from 0% to 18% $Eu^{3+,}$ as calculated by Equation 1, and based on experimental reactant concentrations:

$$\%Eu = mM\ Eu^{3+}/(mM\ Eu^{3+} + mM\ Ce^{3+}) \qquad \textbf{(S1)}$$

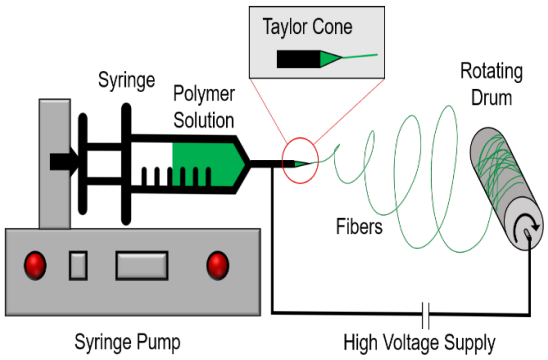

Figure S1. Diagram of electrospinning apparatus.

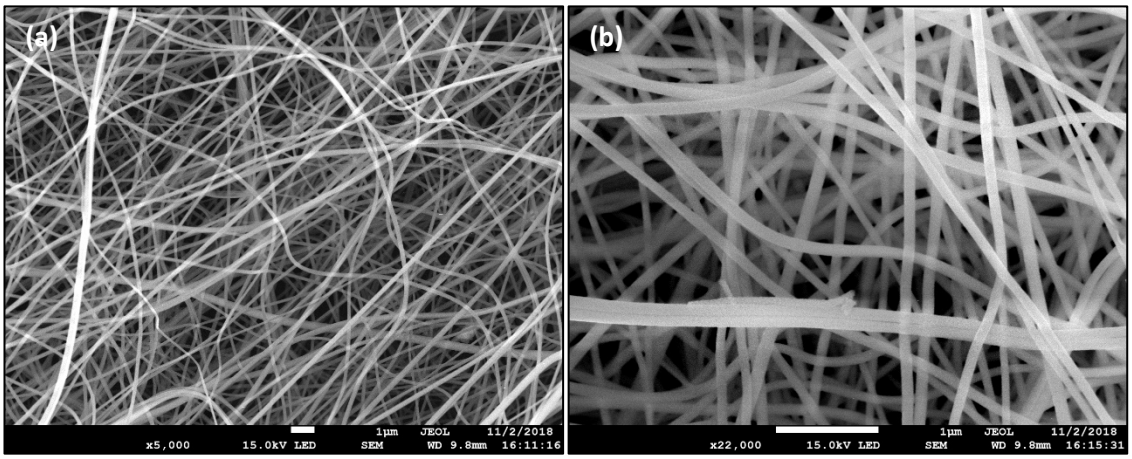

Figure S2. Representative SEM images of (a) unannealed 8% Eu-CeO_2/PVP nanowires, and (b) annealed 8% Eu-CeO_2 nanowires.

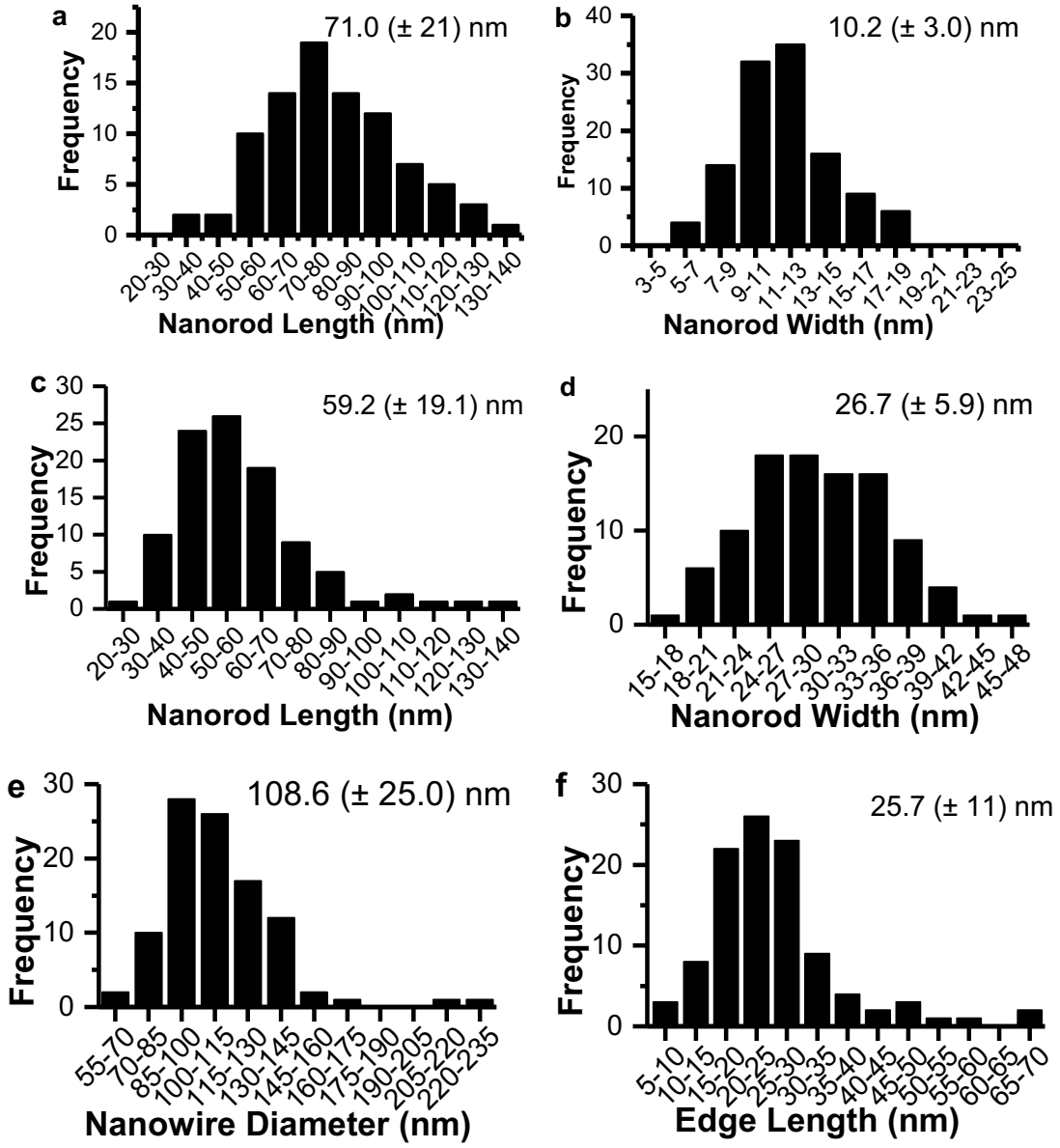

Figure S3. Histograms of 8%-Eu-CeO_2 (a) nanorods length, (b) nanorods width, (c) annealed nanorods length (d) annealed nanorods width, (e) nanowire diameters, and (f) nanocube edge length.

Equation S2. Scherrer formula and associated definitions.Crystalline domain sizes are estimated by use of the Scherrer equation (Equation S2). Here τ is the crystalline domain size in nm, K is the shape constant approximated to be 0.94, λ is the wavelength of the incident x-rays (1.54178 Å for Cu $K_{a)}$, β is the full-width half-max of the CeO_2 (111) peak at 31° and, θ is the Bragg angle, or ½ the 2θ x-ray angle.

$$\tau = \frac{K\lambda}{\beta \cos(\theta)} \quad \textbf{(S2)}$$

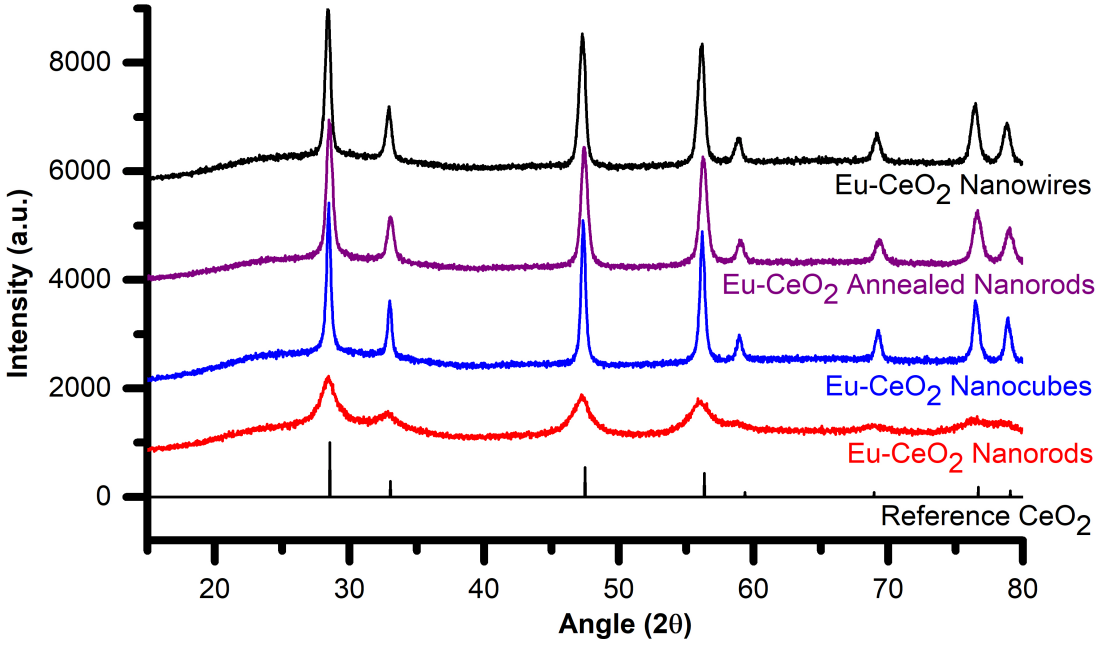

Figure S4. XRD spectra of 8 %Eu-CeO_2 nanomaterials.

Table S1. *A*tomic percentage of Eu^{3+} in CeO_2 nanorods, nanowires, nanocubes, and annealed nanorods, calculated without consideration to oxygen as determined by EDS analysis.

	Undoped	2% Eu	8% Eu	15%
Nanowire	0.0 ± 0.0	2.4 ± 0.7	9.7 ± 1.7	16.2 ± 0.5
Nanorod	0.2 ± 0.2	3.1 ± 1.0	7.9 ± 1.7	15.6 ± 0.7
Annealed Nanorod	1.1 ± 0.9	3.1 ± 0.9	7.0 ± 0.9	15.7 ± 0.4
Nanocube	0.2 ± 0.2	2.9 ± 1.0	6.8 ± 0.9	11.7 ± 0.3

Table S2. Atomic percentage of europium, cerium, and oxygen in CeO_2 nanorods, nanowires, nanocubes, and annealed nanorods as determined by EDS analysis.

		0% Eu-CeO_2	**2% Eu-CeO_2**	**8% Eu-CeO_2**	**15% Eu-CeO_2**
Nanowire	% O	52.5 ± 6.8	51.4 ± 0.9	53.1 ± 4.3	51.1 ± 2.3
	% Ce	47.1 ± 4.8	46.0 ± 2.4	42.3 ± 3.8	41.1 ± 2.2
	% Eu	0.0 ± 0.0	1.15 ± 0.4	4.6 ± 0.9	7.9 ± 0.1
Nanorod	% O	62.7 ± 7.2	68.6 ± 8.0	62.1 ± 5.5	60.5 ± 1.3
	% Ce	37.2 ± 7.2	30.5 ± 8.0	34.2 ± 4.6	32.2 ± 1.9
	% Eu	0.1 ± 0.1	0.9 ± 0.1	3.7 ± 0.9	7.3 ± 1.9
Annealed Nanorod	% O	65.6 ± 6.7	57.8 ± 0.9	60.2 ± 1.9	56.3 ± 3.8
	% Ce	32.1 ± 6.9	40.9 ± 1.3	37.0 ± 2.1	36.7 ± 3.4
	% Eu	0.33 ± 0.3	1.3 ±0. 4	2.8 ± 0.4	6.9 ± 0.4
Nanocube	% O	53.5 ± 0.9	51.9 ± 1.6	54.3 ± 3.6	55.8 ± 1.1
	% Ce	46.4 ±0.9.	46.7 ± 1.2	42.6 ± 3.7	39.0 ± 1.1
	% Eu	0.1 ± 0.1	1.4 ± 0.6	3.1 ± 0.2	5.2 ± 0.1

Table S3. Binding energies and areas from fitted Ce 3d XPS spectra for 8% Eu-CeO_2 nanomaterials and undoped CeO_2 nanorods.

	u	*u'*	*u''*	*u'''*	*v*	*v'*	*v''*	*v'''*
CeO_2 Nanorod								
Binding Energy (eV)	881.89	884.87	888.27	897.89	900.53	903.45	906.73	916.33
Integrated Area	8259.7	4762.6	3694.8	5993.1	5153.2	2168.8	2296.6	4336.1
Eu-CeO_2 Nanorod								
Binding Energy (eV)	881.86	884.69	888.20	898.0	900.61	903.20	906.70	916.37
Integrated Area	6423.7	4434.9	3933.5	5752.9	4034.0	2161.2	2336.1	3710.6
Eu-CeO_2 Annealed Rod								
Binding Energy (eV)	881.95	884.92	888.35	897.74	900.53	903.45	906.97	916.17
Integrated Area	5561.9	1863.9	3506.	5379.1	3551.2	938.2	2143.31	3898.86
Eu-CeO_2 Nanowire								
Binding Energy (eV)	881.9	884.6	888.2	897.9	900.4	902.4	906.9	916.1
Integrated Area	26655	4786	4835	16583	8056	1108	1442	8279
Eu-CeO_2 Nanocube								
Binding Energy (eV)	882.00	883.50	888.04	898.10	901.03	903.89	907.11	916.46
Integrated Area	2287.95	1838.26	1834.6	3172.9	1720.34	293.87	902.894	2021.89

Table S4. Binding energies and integrated areas from fitted O 1s XPS spectra for 8%-Eu-CeO_2 nanomaterials and undoped CeO_2 nanorods.

	O_α		O_β	
	Binding Energy (eV)	Integrated Area	Binding Energy	Integrated Area
CeO_2 Nanorod	528.95	5017.1	531.40	1055.4
Eu-CeO_2 Nanorod	528.99	4282.6	531.39	1478.6
Eu-CeO_2 Annealed Nanorod	528.69	4454.6	531.32	1234.8
Eu-CeO_2 Nanowire	~529.3	15639.2	~531.99	2460.4
Eu-CeO_2 Nanocube	529.16	4657.9	532.04	500.4

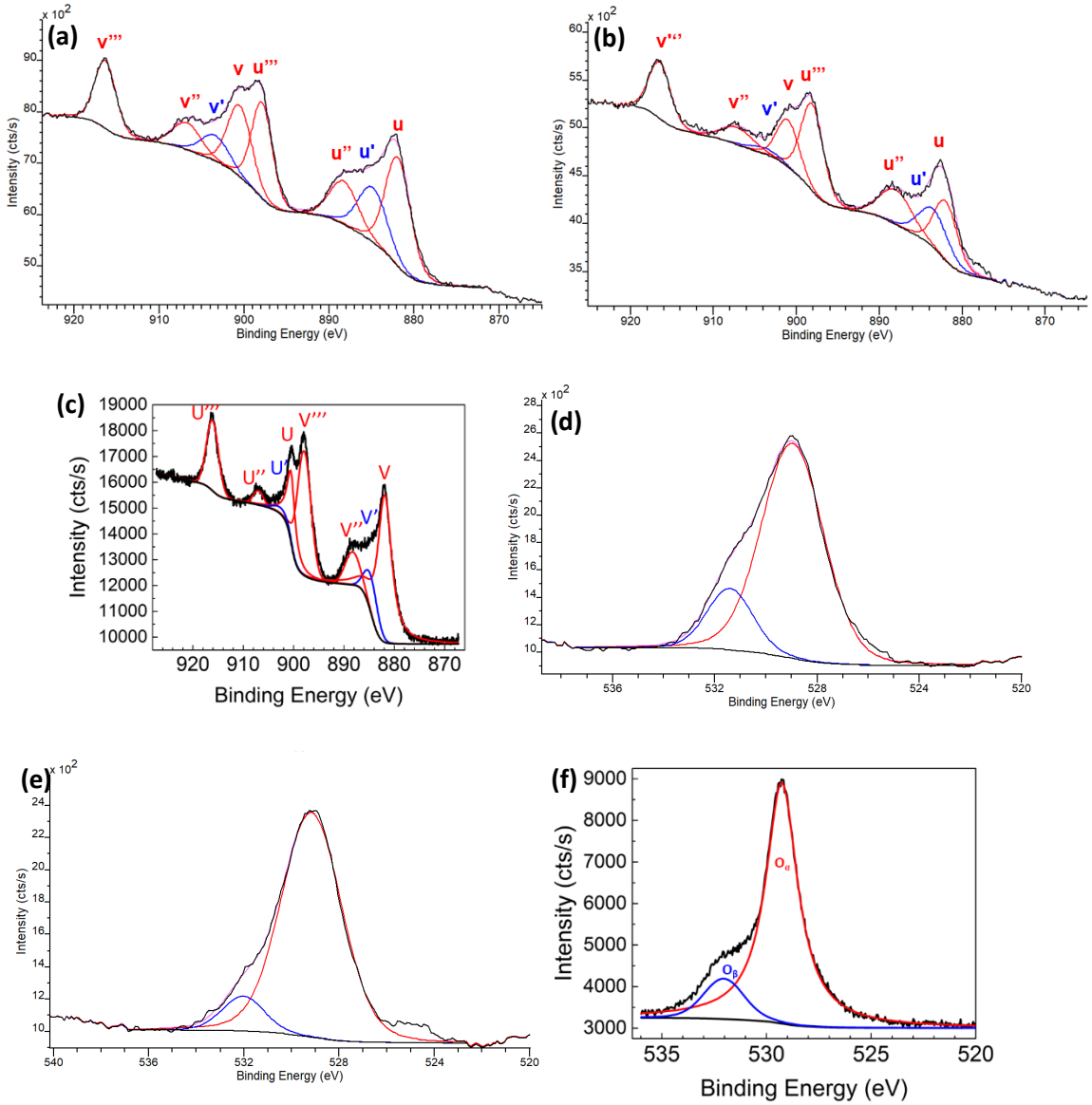

Figure S5. XPS spectra of Ce 3d (a) CeO_2 nanorod, (b) 8% Eu-CeO_2 nanocubes, (c) 8% Eu-CeO_2 nanowires, and O 1s of (d) CeO_2 nanorods, (e) 8% Eu-CeO_2 nanocubes, and (f) 8% Eu-CeO_2 nanowires.

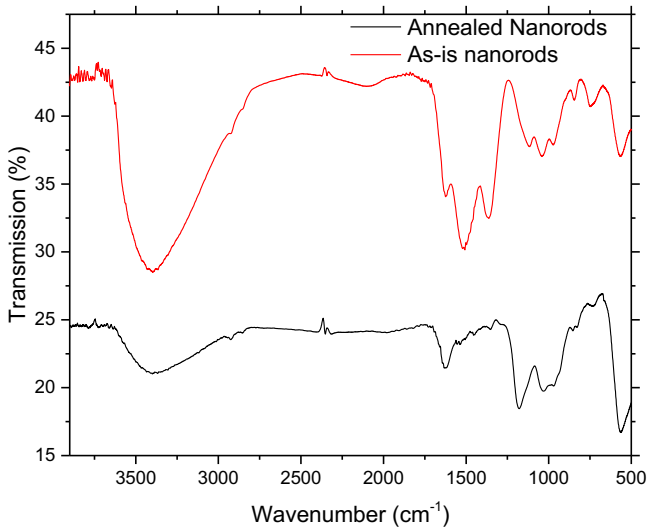

Figure S6. FT IR spectra of cerium oxide nanorods before and after annealing at 600°C.

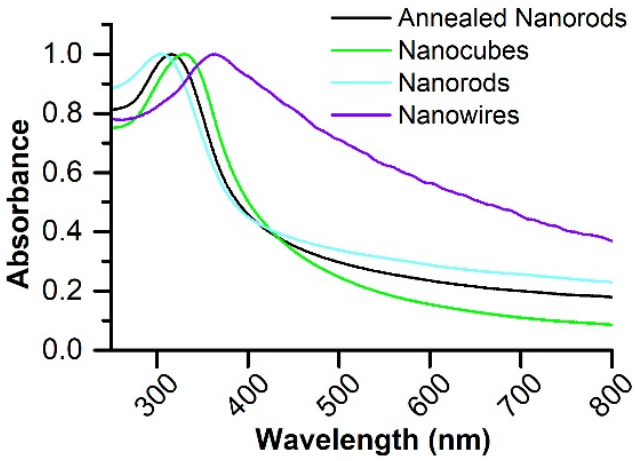

Figure S7. Normalized absorbance spectra of 8 at% Eu-CeO_2 nanowires (75 µg/mL), nanorods (260 µg/mL), nanocubes (112 µg/mL), and annealed nanorods (188 µg/mL).

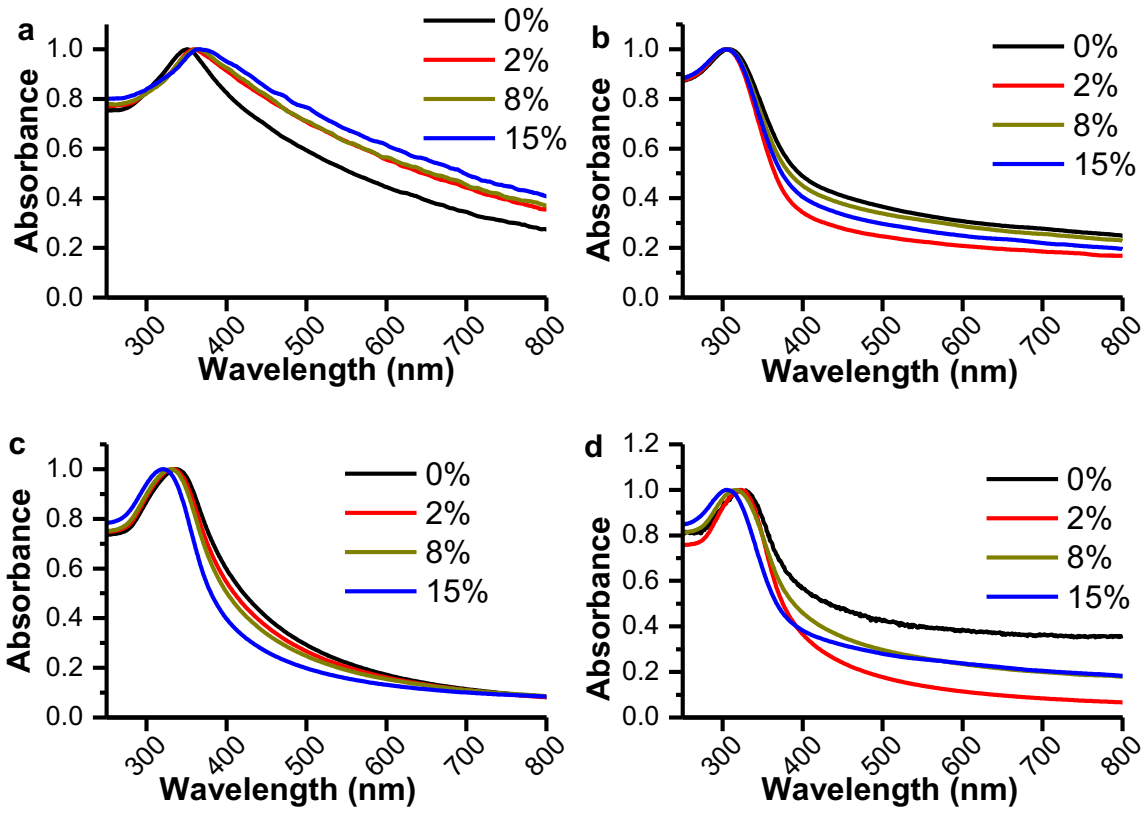

Figure S8. UV-Vis absorbance with varying Eu^{3+} concentration for CeO_2 (a) nanowires, (b) nanorods, (c) nanocubes, and (d) annealed nanorods.

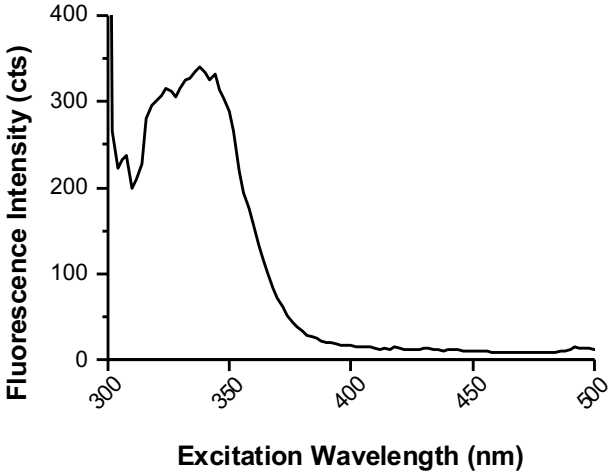

Figure S9. Excitation spectrum for nanocubes measuring emission at 590 nm.

Table S5. Asymmetry ratio of 8% Eu-CeO_2 nanorods with increasing annealing temperature with excitation at 375 nm.

Annealing Temperature	Unannealed	400 °C	500 °C	600 °C	700 °C	800 °C
Asymmetry Ratio	1.99	2.49	2.29	2.32	2.23	2.19