Supporting Information

Controlled synthesis of lanthanide-doped Gd$_2$O$_2$S nanocrystals with a novel excitation-dependent multicolor emissions

Lei Lei,* Shengjun Zhang, Han Xia, Ying Tian, Junjie Zhang, Shiqing Xu*

College of Materials Science and Engineering, China Jiliang University, Hangzhou 310018, P. R. China

Table S1 and Figure S1-S14

Table S1 the detailed conditions for synthesizing Gd$_2$O$_2$S NCs with different morphologies

<table>
<thead>
<tr>
<th>A : B : C</th>
<th>OA:OM:ODE</th>
<th>T[°C]</th>
<th>t[min]</th>
<th>Phase</th>
<th>Morphology</th>
<th>Mean-size [nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 : 0 : 10</td>
<td>1 : 3 : 4</td>
<td>315</td>
<td>60</td>
<td>hexagonal</td>
<td>plate</td>
<td>~7 (D)</td>
</tr>
<tr>
<td>0 : 0 : 10</td>
<td>1 : 3 : 4</td>
<td>315</td>
<td>60</td>
<td>hexagonal</td>
<td>plate</td>
<td>~11 (D)</td>
</tr>
<tr>
<td>5 : 1 : 10</td>
<td>1 : 3 : 4</td>
<td>315</td>
<td>60</td>
<td>hexagonal</td>
<td>plate</td>
<td>~40 (D)</td>
</tr>
<tr>
<td>5 : 1 : 100</td>
<td>1 : 3 : 4</td>
<td>315</td>
<td>60</td>
<td>hexagonal</td>
<td>flower</td>
<td></td>
</tr>
<tr>
<td>A : Na(acac), B : Y(acac)$_3$, C : S, (D) : diameter</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Figure S1 TEM (a) and HRTEM (b) images of Gd$_2$O$_2$S nanoplate with ~7nm in diameter. TEM specimens were dispersed in cyclohexane and ethanol mixture (cyclohexane : ethanol = 3:1) solution. Inset of (a) is the corresponding EDS spectra.
Figure S2 TEM and HRTEM images of Gd$_2$O$_2$S nanoplate prepared through taking the Gd$_2$O$_2$S nanoplate with ~7nm in diameter as seed. TEM specimens were dispersed in cyclohexane and ethanol mixture (cyclohexane : ethanol = 3:1) solution.

Figure S3 (a) XRD patterns of the products prepared under OM/ODE (a) and OA/ODE (b) solvent; (c) and (d) are the TEM images of (a) and (b).

Figure S4 (a) XRD patterns of Gd$_2$O$_2$S NCs prepared with different Na$^+$ concentration (0.5, 2 mmol), bars represent standard hexagonal Gd$_2$O$_2$S crystal (JCPDS 26-1422) data; TEM images of Gd$_2$O$_2$S NCs prepared with different Na$^+$ concentration: (b) 0, (c) 0.5mmol, (d) 2mmol.
Figure S5 (a) XRD pattern of Gd$_2$O$_2$S NCs prepared with only doping Y$^{3+}$ ions (20 mmol%), (b) TEM image of the corresponding Gd$_2$O$_2$S NCs.

Figure S6 TEM images of the Gd$_2$O$_2$S NCs prepared under different reaction conditions: (a) 0min/315°C, (b) 2min/315°C, (c) 5min/315°C, (d) 10min/315°C, (e) 60min/315°C, (f) 60min/270°C.
Figure S7 XRD patterns of Gd$_2$O$_2$S NCs prepared under different conditions: without Y$^{3+}$/Na$^+$ and 1mmol S (a), 5 mmol S (b), 10 mmol S (c), with Y$^{3+}$/Na$^+$ and 5mmol S (d); (e)-(h) are the corresponding TEM images of (a)-(d), respectively.

Figure S8 Decay curves of Tb$^{3+}$: $^5$D$_4$ level in F-NYG: 2%Tb/x%Eu (x=0, 1, 2, 4) samples.
Figure S9 XRD pattern and TEM image of $\text{Y}_2\text{O}_2\text{S}: 2\%\text{Tb}$ NCs.

Figure S10 (a) and (b) are the PLE spectra of F-NYG: 2$\%$Tb ($\text{Y}_2\text{O}_2\text{S}: 2\%\text{Tb}$) and F-NYG: 2$\%$Dy ($\text{Y}_2\text{O}_2\text{S}: 2\%\text{Dy}$), respectively; (c) and (d) are the corresponding PL spectra.

Figure S11 Schematic illustration of the energy transfer mechanism.
Figure S12 Dependence of the integral PL intensity on RE$^{3+}$ (RE = Eu, Tb, Dy, Sm) concentration in F-NYG NCs.

Figure S13 Life time of Tb$^{3+}$: $^5$D$_4$ level as a function of the excitation wavelength for F-NYG: 2%Tb and F-NYG: 2%Tb/2%Eu samples.

Figure S14 PL spectra of F-NYG: 1%Sm/2%Dy NCs under various excitation wavelengths.