Supporting Information

Yolk-shell structured Gd$_2$O$_3$:Eu$^{3+}$ phosphor prepared by spray pyrolysis: Effect of preparation conditions on microstructure and luminescence properties

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**Figure S1.** Schematic diagram of the large scale ultrasonic spray pyrolysis process.

**Figure S2.** Thermogravimetric analysis of the Gd$_2$O$_3$:Eu$^{3+}$ phosphor powders prepared at different temperatures: a) 400 °C, b) 1000 °C.

**Figure S3.** TEM images of the post heat-treated Gd$_2$O$_3$:Eu$^{3+}$ phosphor powders prepared at the temperature of 1000 °C: (a) 900 °C, (b) 1000 °C, (c) 1100 °C, and (d) 1200 °C.

**Figure S4.** N$_2$ adsorption-desorption isotherms measured at 77 K for the Gd$_2$O$_3$:Eu$^{3+}$ yolk-shell phosphor powders post-treated at various temperatures.

**Figure S5.** SEM images of the post heat-treated Gd$_2$O$_3$:Eu$^{3+}$ phosphor powders prepared at the temperature of 1000 °C: (a) 900 °C, (b) 1000 °C, (c) 1100 °C, and (d) 1200 °C.

**Figure S6.** Morphologies and dot-mapping images of the post heat-treated Gd$_2$O$_3$:Eu$^{3+}$ phosphor powders at 1100 °C: (a) TEM image of the powder, (b) HR-TEM image of the powder, (c) SAED pattern of the powder, and (d) dot-mapping images of the powder.
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