Supporting Information

**Al$_2$O$_3$/Yttrium-compound core-shell structure formation with burst nucleation: a process driven by electrostatic attraction and high surface energy**

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Table S1. The residual ions in the solution after filtration measured by the inductively coupled plasma emission spectrometer (ICP-AES, IRIS Intrepid II XSP, Thermo Electron Corporation, USA). It is confirmed that there is little Y ions washed away.

The stoichiometry of YAG can be realized with high precise.

<table>
<thead>
<tr>
<th>Element</th>
<th>1st filtration (ppm)</th>
<th>2nd filtration (ppm)</th>
<th>3rd filtration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.03(1)</td>
<td>0.03(1)</td>
<td>0.01(1)</td>
</tr>
<tr>
<td>Y</td>
<td>0.45(2)</td>
<td>0.13(1)</td>
<td>0.24(1)</td>
</tr>
</tbody>
</table>
Figure S1. XRD patterns of $\alpha$-Al$_2$O$_3$ (a); the mid-product precursor obtained from the suspension at pH=2.6 (b); the YAG precursor obtained from the suspension at pH=6.8 (c); and YAG particles calcined at 1250°C for 2h (d).

The XRD patterns (a-c) are similar and all corresponding to rhombohedral Al$_2$O$_3$ ($\alpha$-Al$_2$O$_3$, PDF#10-0173). The difference is that the diffraction intensity become weak with reaction process and there is an amorphous diffraction is noticed in pattern (c) around 30 °. It implies the increase of the shell thickness during the homogeneous precipitation process. XRD pattern (d) is identified as pure Y$_3$Al$_5$O$_{12}$ phase (PDF#72-1315), indicating a complete phase transition.
Figure S2. The final YAG precursor under high electron explore. The surface of the material is easily decomposed. Based on the stability of $a$-$\text{Al}_2\text{O}_3$ and the unstability of Y-compounds, the shell structure is deemed as Y-compound.

Figure S3. The photographs of the as-obtained transparent ceramics sintering from the powders obtained via the partial wet chemical route. The transparency of the ceramics are good, indicating the good sintering property of the as-obtained YAG powders.
Figure S4. FTIR spectra of the pure Al₂O₃ (curve a), Al₂O₃-NH₄HCO₃ (curve b) in the synthesis process.

To certificate if the carbonate group can adsorb on the surface of Al₂O₃, FTIR spectrum of Al₂O₃ nanoparticles collected from Al₂O₃-NH₄HCO₃ was taken. The FTIR spectrum of Al₂O₃-NH₄HCO₃ (Fig. S4, b) have characteristic adsorption of OH⁻ groups whose peak at 1670 and 3700-3000 cm⁻¹ centered at 3440 cm⁻¹, CO₃²⁻ whose peak at 1375 and 1450 cm⁻¹, is quite different from the FTIR spectra of pure Al₂O₃ (Fig. S4, a). It indicates that the surface of bar Al₂O₃ can adsorb some groups hydrolyzed from NH₄HCO₃ after intense stirring in Al₂O₃-NH₄HCO₃ system.
Figure S5. The pH evolution of different reaction system: Al$_2$O$_3$-Y(NO$_3$)$_3$-NH$_4$HCO$_3$ system (a), Al$_2$O$_3$-Y(NO$_3$)$_3$-Urea system with PAA as surfactant (b), and Al$_2$O$_3$-Y(NO$_3$)$_3$-Urea system (c).