Supporting Information

Phase controlled synthesis of SnSe and SnSe$_2$ hierarchical nanostructures made of single crystalline ultrathin nanosheets

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Fig. S1 XPS spectra of the Sn 3d orbital and the Se 3d orbital of SnSe HNs.

Fig. S2 EDS spectrum of SnSe HNs.
Fig. S3 XRD patterns of the synthesized SnSe HNs with different reaction times.

Fig. S4 XPS spectra of the Sn 3d orbital and the Se 3d orbital of SnSe$_2$ HNs.
Fig. S5 EDS spectrum of SnSe$_2$ HNs.

Fig. S6 TEM images of SnSe$_2$ HNs showing sheet thickness.

Fig. S7 XRD patterns of the products obtained with different amounts of oleic acid.
Fig. S8 SEM images the products obtained with different amounts of oleic acid (a) 100, (b) 300, and (c and d) 500 µL.

Fig. S9 (a) Diffuse reflectance spectrum for SnSe HNs. Direct and indirect bandgaps were calculated from plots of $[F(R)hv]^2$ and $[F(R)hv]^{1/2}$ vs energy, shown in panels b and c, respectively.
Fig. S10 (a) Diffuse reflectance spectrum for SnSe$_2$ HNs. Direct and indirect bandgaps were calculated from plots of $[F(R)h\nu]^2$ and $[F(R)h\nu]^{1/2}$ vs energy, shown in panels b and c, respectively.

Fig. S11 Diffuse reflectance spectra of SnSe HNs as a function of reaction time.
Table S1. Calculated direct and indirect bandgaps of SnSe HNs as function of reaction time.

<table>
<thead>
<tr>
<th>Reaction time (h)</th>
<th>Direct bandgap (eV)</th>
<th>Indirect bandgap (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1.60</td>
<td>0.96</td>
</tr>
<tr>
<td>15</td>
<td>1.56</td>
<td>0.97</td>
</tr>
<tr>
<td>18</td>
<td>1.50</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Fig. S12 (a) Diffuse reflectance spectrum for SnSe-SnSe$_2$ composite HNs. Direct and indirect bandgaps were calculated from plots of [F(R)hv]$^2$ and [F(R)hv]$^{1/2}$ vs energy, shown in panels b and c, respectively.
Fig. S13 \( \text{N}_2 \) adsorption-desorption isotherm and pore size distribution plots of SnSe HNs.

Fig. S14 \( \text{N}_2 \) adsorption-desorption isotherm and pore size distribution plots of SnSe\(_2\) HNs.
Fig. S15  SEM images of (a) SnSe, and (b) SnSe$_2$ HNs counter electrodes annealed at 500 °C in N$_2$ atmosphere.

Fig. S16  Cross- sectional SEM images of (a) SnSe, and (b) SnSe$_2$ HNs counter electrodes annealed at 500 °C in N$_2$ atmosphere.
**Fig. S17** XRD patterns of SnSe HNs counter electrodes (a) before, and (b) after annealed at 500 °C in N₂ atmosphere.

**Fig. S18** XRD patterns of SnSe₂ HNs counter electrodes (a) before, and (b) after annealed at 500 °C in N₂ atmosphere.
**Fig. S19** SEM images of SnSe HNs (a) as synthesized (b) stored at ambient conditions for 9 months.