Electronic Supplementary Information

Size-dependence of optical and mechanical properties of Si₃N₄ nanobelts controlled by flow rate

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Fig. S1 A XRD pattern of the products synthesized with 50ml/min of N$_2$ at 1450°C.
**Fig. S2** The macroscopic morphology of the achieved products synthesized with 50ml/min of N$_2$. 
Fig. S3 A typical EDX spectrum of the tip of Si₃N₄ NB.
Fig. S4 A schematic illustration for the growth process of Si$_3$N$_4$ NBs with three stages.
### Table S1 The thermodynamics data of the related compounds

<table>
<thead>
<tr>
<th></th>
<th>SiO₂</th>
<th>SiO</th>
<th>CO</th>
<th>C</th>
<th>CO₂</th>
<th>Si₃N₄</th>
<th>N₂</th>
</tr>
</thead>
</table>

**Details of the thermodynamic calculations:**

The change in Gibbs free energy is the difference of Gibbs free energy between the reaction products and the reactants.²

\[
\Delta G = \sum (n_i \Delta G)_{product} - \sum (m_i \Delta G)_{reactant}
\]

**Reaction (1):** 3SiO(g) + 3C(s) + 2N₂(g) = Si₃N₄(s) + 3CO(g)

\[
\Delta G_{2⁹⁸} = \Delta G_{Si₃N₄} + 3\Delta G_{CO} - 3\Delta G_{SiO} - 2\Delta G_{N₂} = -778.433 + (169.474 \times 3) + (163.495 \times 3) - (169.474 \times 3) - (57.128 \times 2) = -1286.855 + 609.877 = -676.978 \text{ kJ mol}^{-1}
\]

\[
\Delta G_{1₈⁰⁰} = \Delta G_{Si₃N₄} + 3\Delta G_{CO} - 3\Delta G_{SiO} - 2\Delta G_{N₂} = -1173.986 + (519.873 \times 3) - (538.622 \times 3) - (38.183 \times 3) - (397.969 \times 2) = -2733.605 + 2526.353 = -207.252 \text{ kJ mol}^{-1}
\]

**Reaction (2):** 3SiO(g) + 3CO(g) + 2N₂(g) = Si₃N₄(s) + 3CO₂(g)

\[
\Delta G_{2⁹⁸} = \Delta G_{Si₃N₄} + 3\Delta G_{CO} - 3\Delta G_{SiO} - 3\Delta G_{CO} - 2\Delta G_{N₂} = -778.433 + (169.474 \times 3) + (163.495 \times 3) - (169.474 \times 3) - (57.128 \times 2) = -2150.153 + 1113.163 = -1036.99 \text{ kJ mol}^{-1}
\]

\[
\Delta G_{1₈⁰⁰} = \Delta G_{Si₃N₄} + 3\Delta G_{CO} - 3\Delta G_{SiO} - 3\Delta G_{CO} - 2\Delta G_{N₂} = -1173.986 + (519.873 \times 3) - (538.622 \times 3) - (38.183 \times 3) - (397.969 \times 2) = -3752.123 + 3971.423 = 219.3 \text{ kJ mol}^{-1}
\]

**Reaction (3):** 3SiO₂(s) + 6C(s) + 2N₂(g) = Si₃N₄(s) + 6CO(g)

\[
\Delta G_{2⁹⁸} = \Delta G_{Si₃N₄} + 6\Delta G_{CO} - 3\Delta G_{SiO₂} - 6\Delta G_{C} - 2\Delta G_{N₂} = -778.433 + (169.474 \times 6) + (923.219 \times 3) - (1.712 \times 6) - (57.128 \times 2) = -4293.224 + 4307.255 = 14.031 \text{ kJ mol}^{-1}
\]

**Reaction (4):** 3SiO₂(s) + 6CO(g) + 2N₂(g) = Si₃N₄(s) + 6CO₂(g)
\[ \Delta G_{298} = \Delta G_{\text{Si}_3\text{N}_4} + 6\Delta G_{\text{CO}_2} - 3\Delta G_{\text{SiO}_2} - 6\Delta G_{\text{CO}} - 2\Delta G_{\text{N}_2} = -778.433 + (-457.240 \times 6) - 923.219 \times 3) - (-169.474 \times 6) - (-57.128 \times 2) = -3521.873 + 3900.757 = 378.884 \text{kJ mol}^{-1} \]

\[ \Delta G_{1800} = \Delta G_{\text{Si}_3\text{N}_4} + 6\Delta G_{\text{CO}_2} - 3\Delta G_{\text{SiO}_2} - 6\Delta G_{\text{CO}} - 2\Delta G_{\text{N}_2} = -1173.986 + (-859.379 \times 6) - 1094.073 \times 3) - (-519.873 \times 6) - (-397.969 \times 2) = -6330.26 + 7197.395 = 867.135 \text{kJ mol}^{-1} \]

The changes in Gibbs free energy as a function of temperatures for reactions (1)-(4) have been added to show the results of the thermodynamic calculations.

**Fig. S5** The changes in Gibbs free energy as a function of temperature for reactions (1)-(4).
Fig. S6 A typical elemental area scanning of Si$_3$N$_4$ NBs.
Fig. S7 A schematic illustration for the model of nanoindentation in the system of SEM/SPM.

References