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Electronic Supplementary Information

Size-dependence of optical and mechanical properties of Si_3N_4 nanobelts controlled by flow rate

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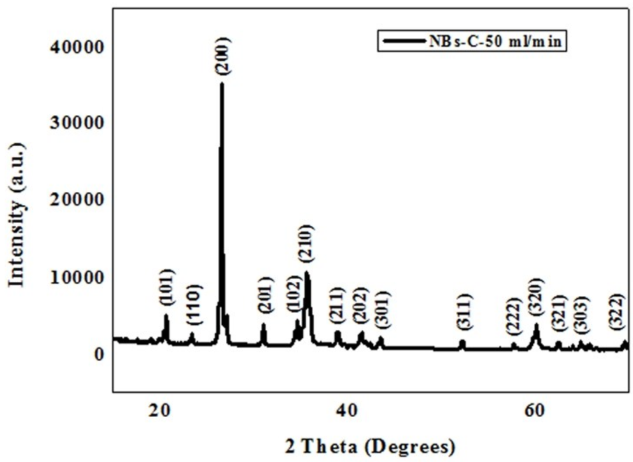

Fig. S1 A XRD pattern of the products synthesized with 50ml/min of N_2 at 1450℃.

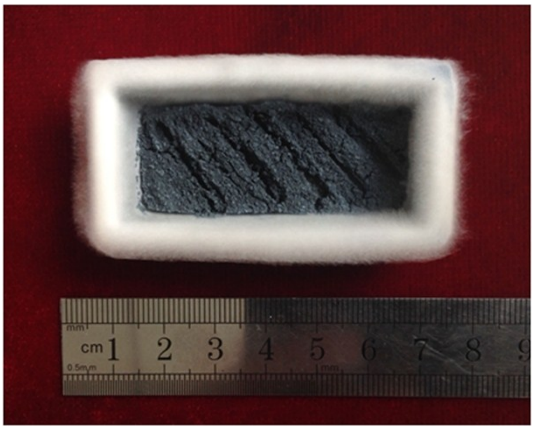

Fig. S2 The macroscopic morphology of the achieved products synthesized with 50ml/min of N_2.

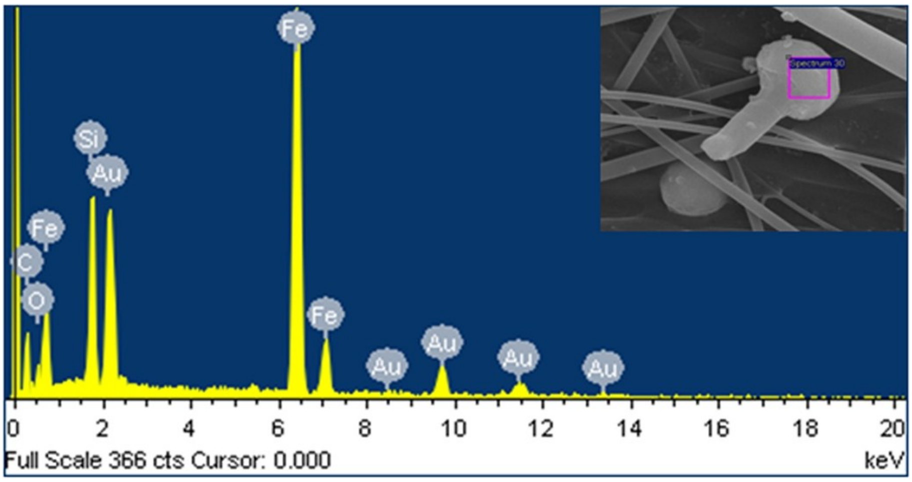

Fig. S3 A typical EDX spectrum of the tip of Si_3N_4 NB.

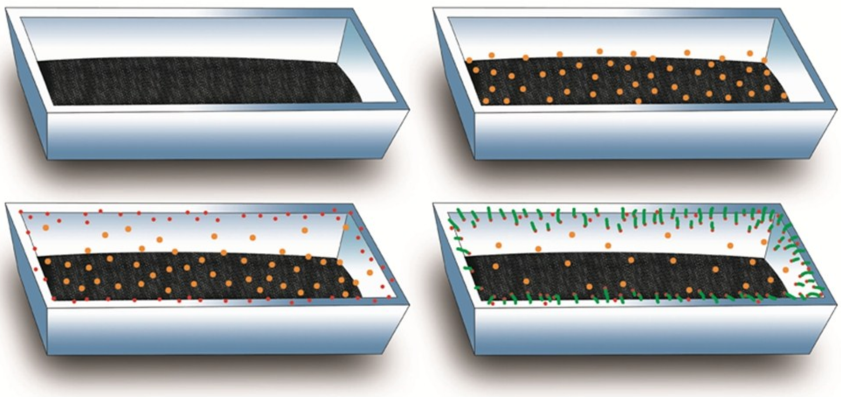

Fig. S4 A schematic illustration for the growth process of Si_3N_4 NBs with three stages.

Table S1 The thermodynamics data of the related compounds[1]

	SiO_2	SiO	CO	C	CO_2	Si_3N_4	N_2
G_{298}(kJ mol^{-1})	-923.219	-163.495	-169.474	-1.712	-457.240	-778.433	-57.128
G_{1800}(kJ mol^{-1})	-1094.073	-538.622	-519.873	-38.183	-859.379	-1173.986	-397.969

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]

$\Delta G=\sum(n_iG)_{product}-\sum(m_iG)_{reactant}$

Reaction（1）： $3SiO(g) + 3C(s) + 2N_2(g) = Si_3N_4(s) + 3CO(g)$

$\Delta G_{298}=\Delta G_{Si3N4}+3\Delta G_{CO}-3\Delta G_{SiO}-3\Delta G_C-2\Delta G_{N2}=-778.433+(-169.474\times3)- (-163.495\times3)-(-1.712\times3)- (-57.128\times2)=-1286.855+609.877= -676.978$kJ mol^{-1}

$\Delta G_{1800}=\Delta G_{Si3N4}+3\Delta G_{CO}-3\Delta G_{SiO}-3\Delta G_C-2\Delta G_{N2}=-1173.986+(-519.873\times3)- (-538.622\times3)- (-38.183\times3)- (-397.969\times2)=-2733.605+2526.353= -207.252$kJ mol^{-1}

Reaction（2）： $3SiO(g) + 3CO(g) + 2N_2(g) = Si_3N_4(s) + 3CO_2(g)$

$\Delta G_{298}=\Delta G_{Si3N4}+3\Delta G_{CO2}-3\Delta G_{SiO}-3\Delta G_{CO}-2\Delta G_{N2}=-778.433+(-457.240\times3)- (-163.495\times3)- (-169.474\times3)- (-57.128\times2)=-2150.153+1113.163= -1036.99$kJ mol^{-1}

$\Delta G_{1800}=\Delta G_{Si3N4}+3\Delta G_{CO2}-3\Delta G_{SiO}-3\Delta G_{CO}-2\Delta G_{N2}=-1173.986+(-859.379\times3)- (-538.622\times3)- (-519.873\times3)- (-397.969\times2)=-3752.123+3971.423= 219.3$kJ mol^{-1}

Reaction（3）： $3SiO_2(s) + 6C (s) + 2N_2(g) = Si_3N_4(s) + 6CO(g)$

$\Delta G_{298}=\Delta G_{Si3N4}+6\Delta G_{CO}-3\Delta G_{SiO2}-6\Delta G_C-2\Delta G_{N2}=-778.433+(-169.474\times6)- (-923.219\times3)- (-1.712\times6)- (-57.128\times2)=-1795.277+2794.185= 998.908$kJ mol^{-1}

$\Delta G_{1800}=\Delta G_{Si3N4}+3\Delta G_{CO}-3\Delta G_{SiO2}-6\Delta G_C-2\Delta G_{N2}=-1173.986+(-519.873\times6)- (-1094.073\times3)- (-38.183\times6)- (-397.969\times2)=-4293.224+4307.255= 14.031$kJ mol^{-1}

Reaction（4）： $3SiO_2(s) + 6CO (g) + 2N_2(g) = Si_3N_4(s) + 6CO_2(g)$

$\Delta G_{298}=\Delta G_{Si3N4}+6\Delta G_{CO2}-3\Delta G_{SiO2}-6\Delta G_{CO}-2\Delta G_{N2}=-778.433+(-457.240\times6)-(-923.219\times3)-(-169.474\times6)-(-57.128\times2)=-3521.873+3900.757=378.884 kJ\ mol^{-1}$

$\Delta G_{1800}=\Delta G_{Si3N4}+6\Delta G_{CO2}-3\Delta G_{SiO2}-6\Delta G_{CO}-2\Delta G_{N2}=-1173.986+(-859.379\times6)-(-1094.073\times3)-(-519.873\times6)-(-397.969\times2)=-6330.26+7197.395=867.135 kJ\ mol^{-1}$

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.

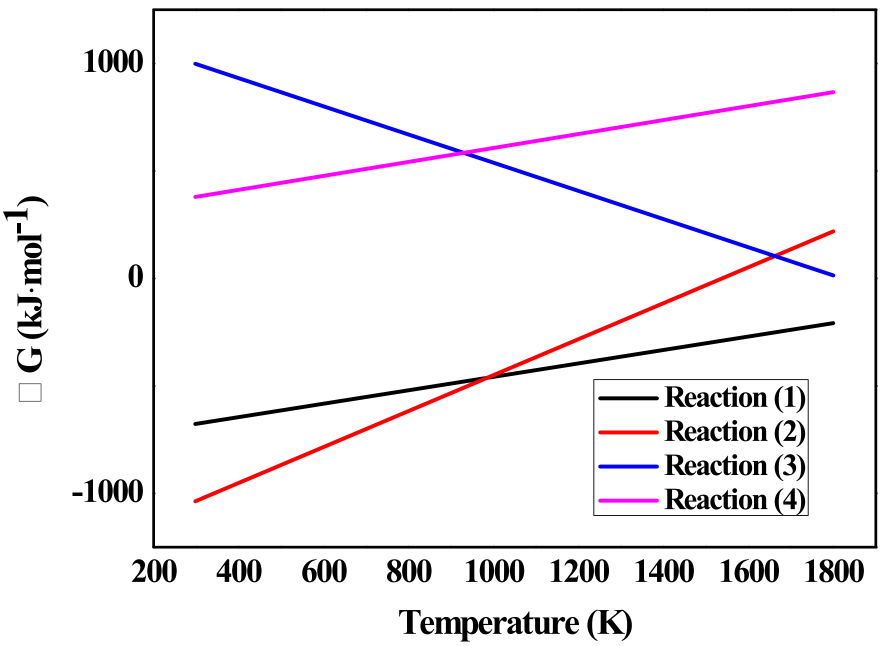

Fig. S5 The changes in Gibbs free energy as a function of temperature for reactions (1)-(4).

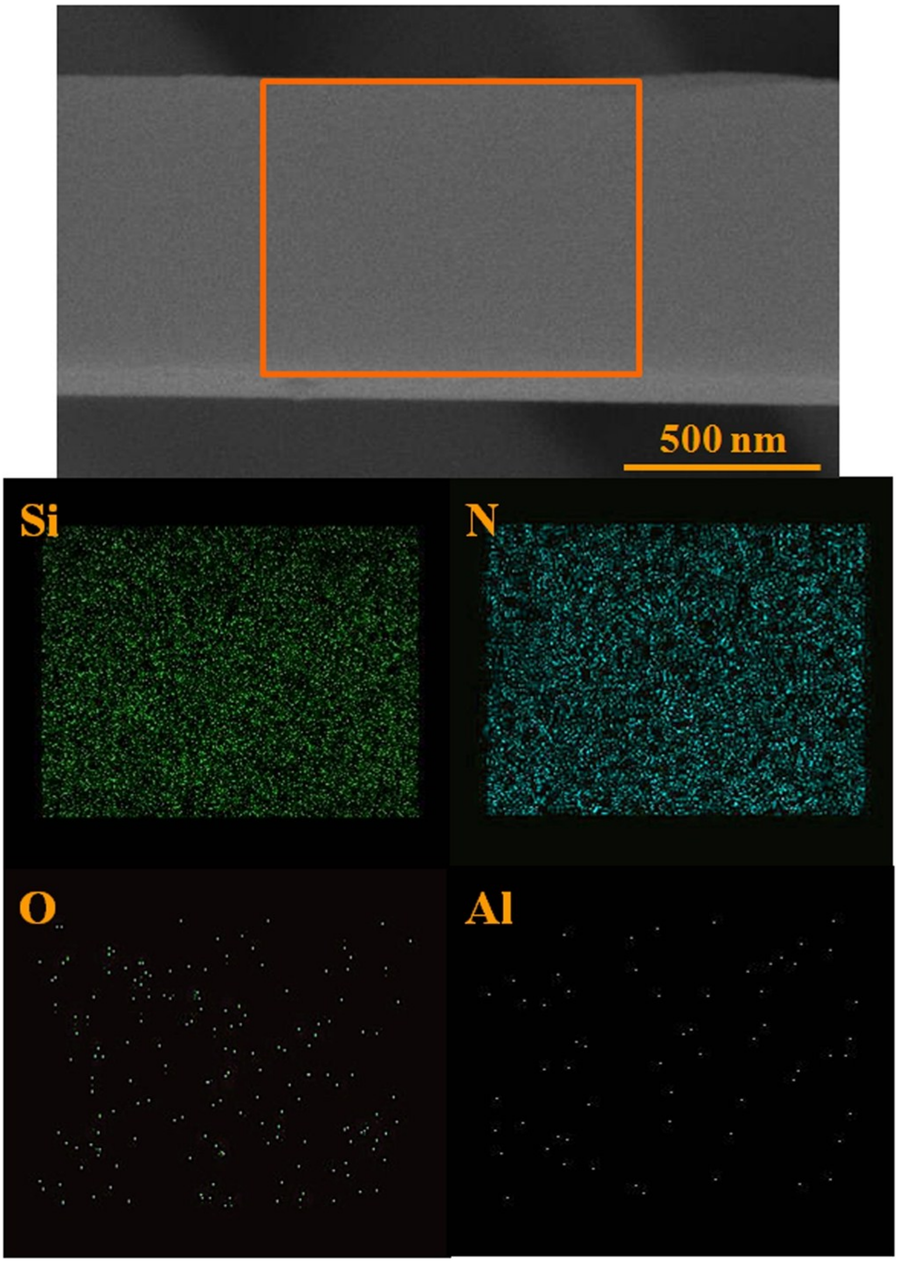

Fig. S6 A typical elemental area scanning of Si_3N_4 NBs.

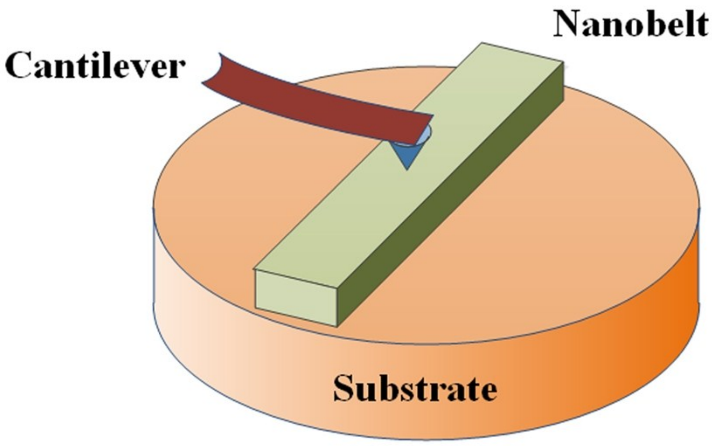

Fig. S7 A schematic illustration for the model of nanoindentation in the system of SEM/SPM.

References

1 I. Barin and G. Platzki, *Thermochemical Date of Pure Substances* 3rd edn, 1995 (Weinheim: VCH).

2 S. Liu, Q.J. Zhang, *Rare Met. Cem. Carbides*, 2006, **33**, 60-62.