Sintering of $SiC-TiC-TiB_2$ Hard Materials

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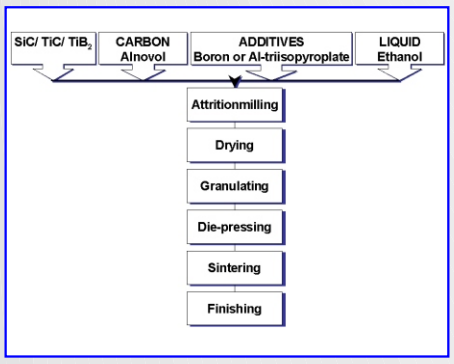
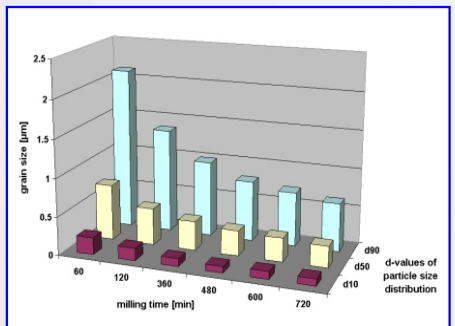
Goal

The goal of the investigation is the characterisation of green bodies and sintering properties of ceramic composites in the quasiternary system SiC-TiC-TiB_2. Manufacturing is done by conventional processing via the powder route. Thermochemical modelling should be applied to characterize the influence of oxide reduction during the sintering process.

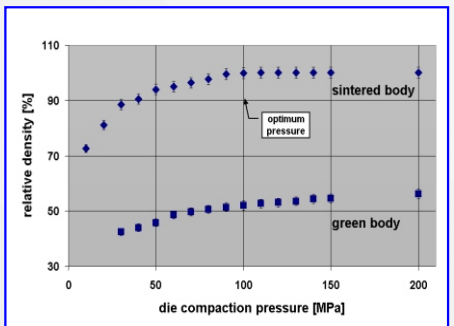
Experimental



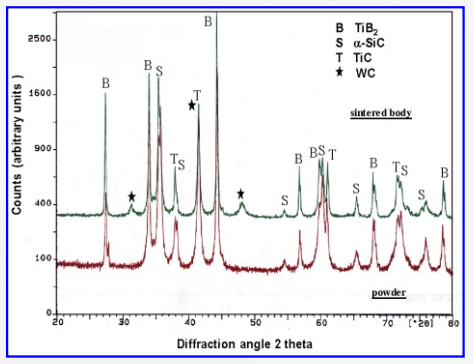
Preparation



Grain size, effect of milling time

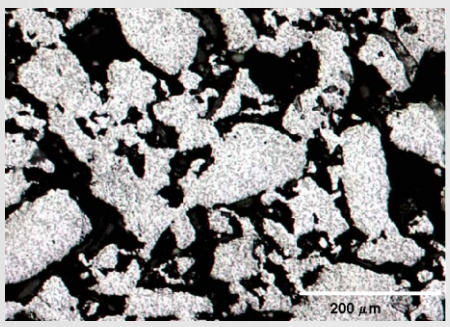


Influence of die compaction pessure

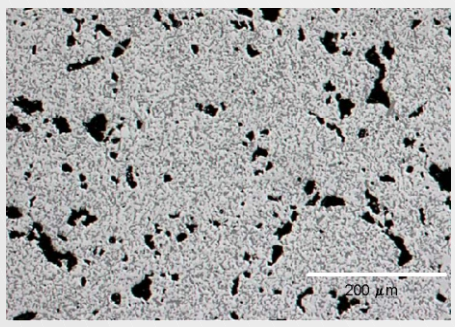


Diffraction pattern powder-sintered body

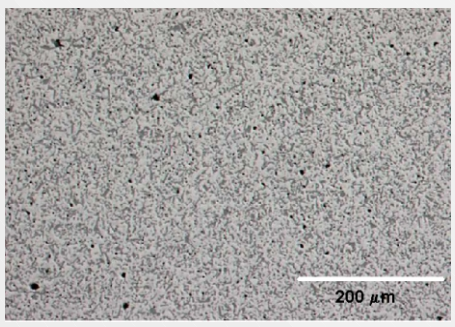
Microstructure



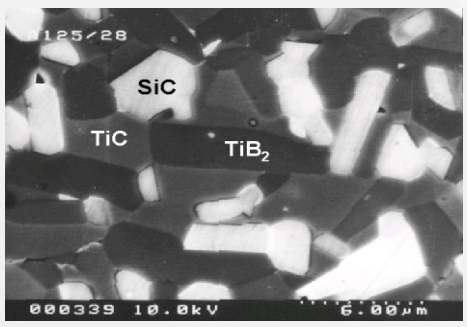
Die compaction pessure: 10 MPa



50 MPa

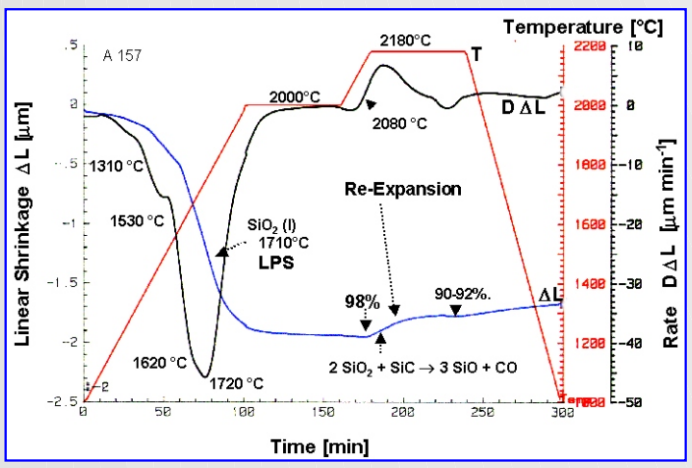


90 MPa

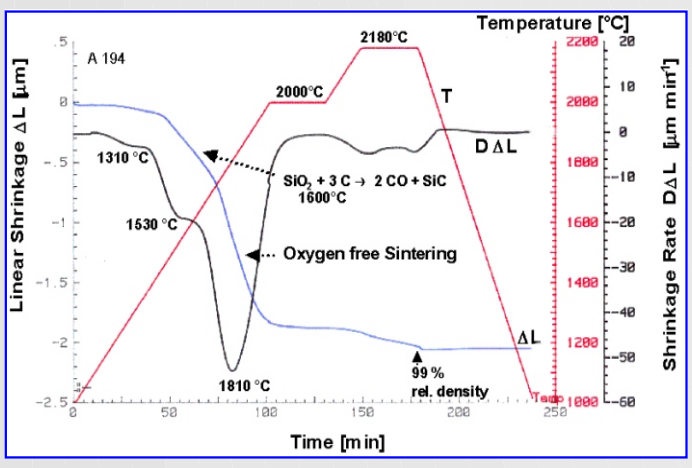


SEM fully dense microstructure

Sintering process



Dilatometric study of sintering process, carbon deficiency



Dilatometric study of sintering process, carbon excess

Thermochemical analysis

Between 1300 °C and 1540 °C

$SiC + TiO_2$	→ $SiO_2 + TiC$
$1{,}5\ TiC + B_2O_3$	→ $1{,}5\ TiO_2 + 2\ B + 1{,}5\ C$
$1{,}5\ SiC + 1{,}5\ TiO_2$	→ $1{,}5\ SiO_2 + 1{,}5\ TiC$
$TiC + 2\ B$	→ $TiB_2 + C$
$2{,}5\ SiC + TiO_2 + B_2O_3$	→ $2{,}5\ SiO_2 + TiB_2 + 2{,}5\ C$

Between 1540 °C and 1600 °C

$TiB_2 + 1{,}5\ SiO_2$	→ $B_2O_3 + 1{,}5\ Si + Ti$
$Ti + C$	→ TiC
$1{,}5\ Si + 1{,}5\ C$	→ $1{,}5\ SiC$
$TiB_2 + 1{,}5\ SiO_2 + 2{,}5\ C$	→ $B_2O_3 + TiC + 1{,}5\ SiC$

After 1600 °C

Carbon deficiency:
$2\ SiO_2 + SiC \rightarrow 3\ SiO + CO$

Carbon excess:
$SiO_2 + 3\ C \rightarrow 2\ CO + SiC$

Conclusions

Applied compaction pressures below a threshold of 90 MPa lead to porous microstructures. During sintering carbon plays a central role for a complete densification since its ratio to oxygen is decisive for the stabilization of silicon carbide at higher temperatures. In case of carbon deficiency oxyden remains in the microstructure in form of SiO_2 during sintering and then reacting with SiC to form a mixture of SiO and CO gas. When enough carbon is present oxygen is completely removed from the microstructure in form of CO.

Literature: Wäsche, R.: Ceramic Trans. 124, 185-196 (2001)
Wäsche, R., et. al.: Key Eng. Mat. 264-268, 213-218 (2004)