Alternative processing route of WC-Ni cemented carbides

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Context

WC-Ni are processed by powder metallurgy

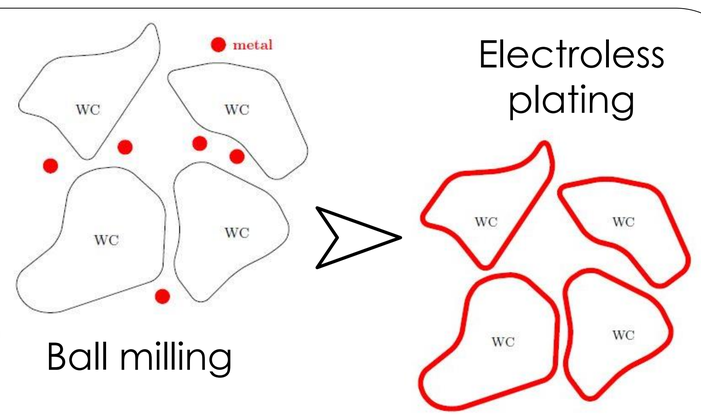
→ Press and Sinter route

→ Milling is necessary for mixing powders

→ Long times and high energy needed for good homogenisation

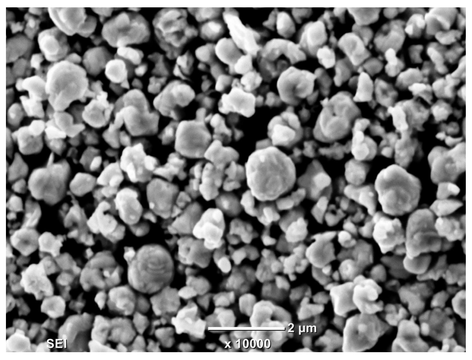
Proposition: coating of the WC particles by electroless plating (reduction of Ni salt by $NaBH_4$)

Advantages: time and cost saving (no milling and no pre-treatment needed)



Methods

WC powder



Electroless bath parameters

Compound	Formula	Content (per L)
Source of Ni ions	$NiCl_2 \cdot 6H_2O$	24 g
Complexing agent	$C_2H_8N_2$	60 ml
Reducing agent	$NaBH_4$	0.6 g
pH regulator	NaOH	39 g
Stabilizer	$PbWO_3$	2 ml / 0 ml
Temperature	-	85°C / 90 °C
Time	-	5 min

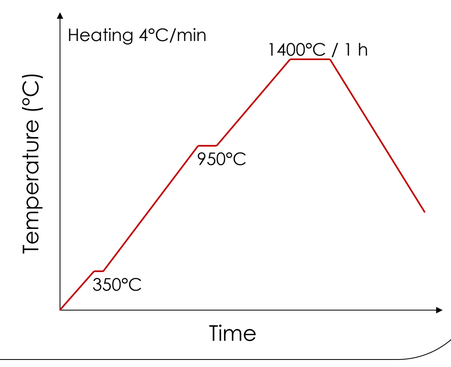
Post-processing

- Washing in demineralized water
- Centrifugation for recovery
- Drying 100°C 12 h

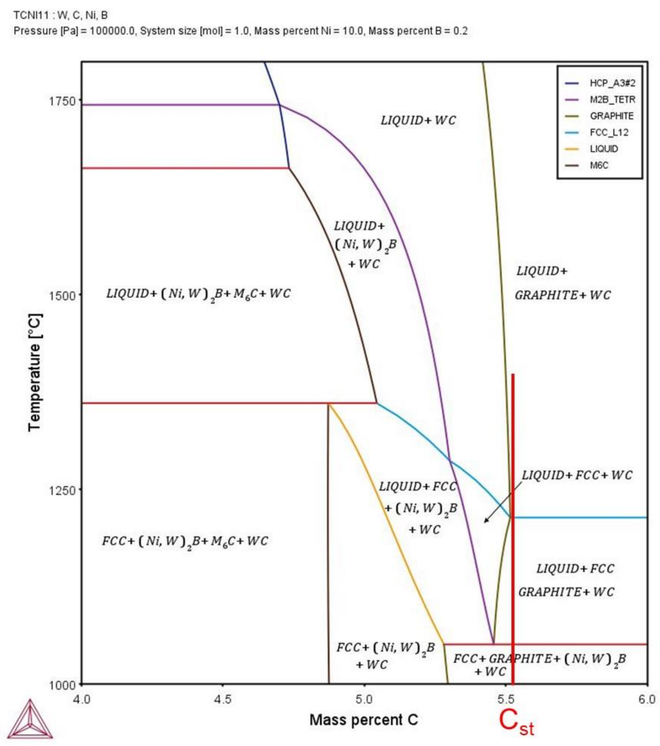
Thermodynamic modelling

- Pseudo-binary W-C-Ni-B phase diagram
- Fixed Ni (10 wt.%) and B (0.2 wt.%) contents

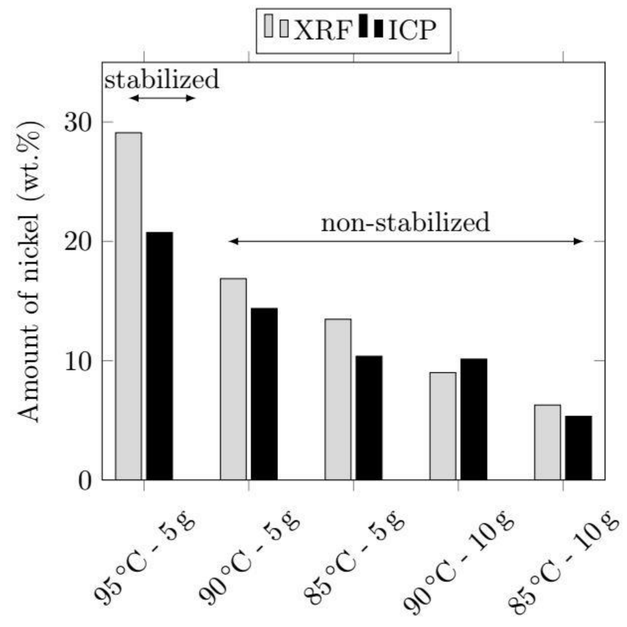
Sintering

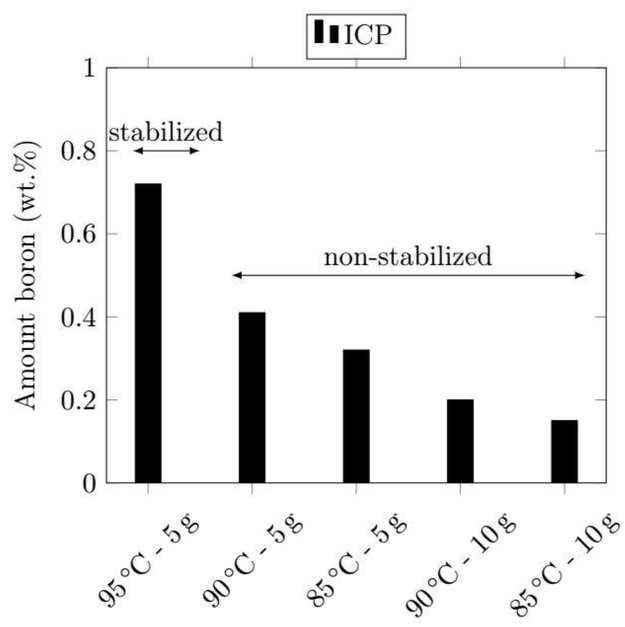


Results



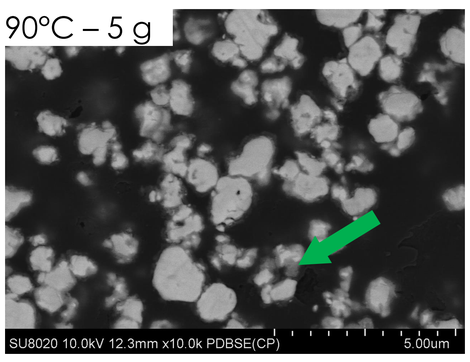
Expected extra phases : graphite and $(Ni,W)_2B$

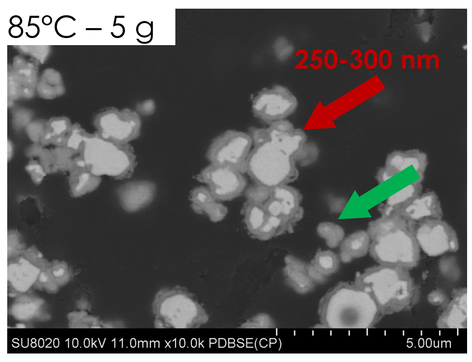


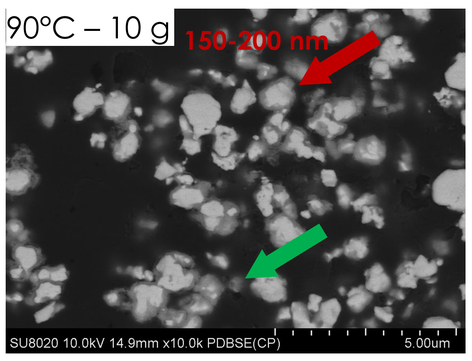


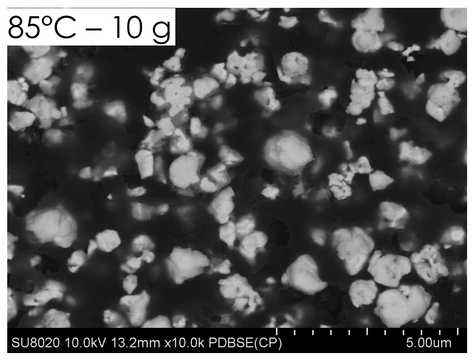
Plating temperature 95°C → rapid reaction that is difficult to control

Plating temperature 85/90°C → suitable Ni content for applications (cutting tools or wear parts)
→ co-deposition of B



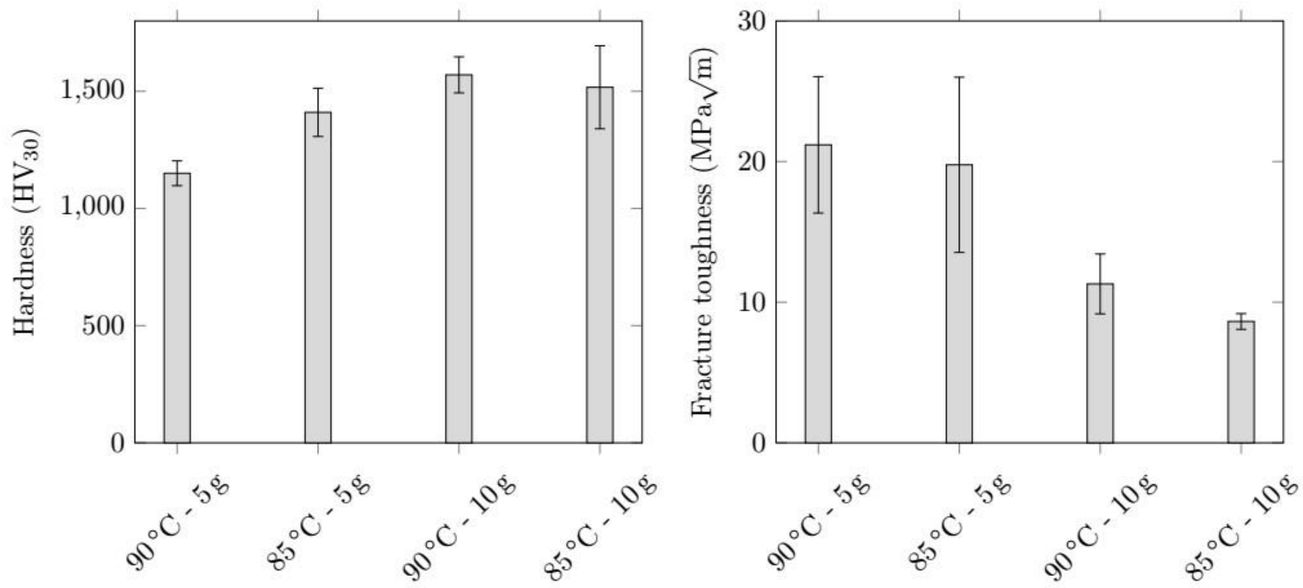






Red arrows → coated WC particles with NiB

Green arrows → Ni particles in the bath



High standard deviations → inhomogeneous microstructures (η-phase and/or nickel pools)

90°C – 5 g → low hardness (1100-1200 HV_{30}) due to high nickel content and large WC grains

90°C – 10 g → higher hardness (around 1500 HV_{30}) due to more homogeneous microstructure

Conclusions et perspectives

Optimized sintered part reached a hardness of 1570 ± 70 HV_{30} and a facture toughness of 11.3 ± 2.1 MPa√m (plating conditions: 90°C and 10 g).

Optimization of the sintering temperature needed to reduce η-phase and thus to improve mechanical properties

Acknowledgments

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