Microstructural design of Ti(CN) based cermets

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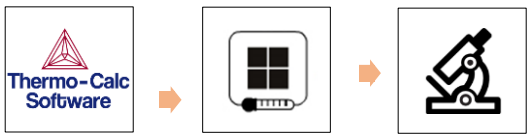
Motivation

Ti(CN) based cermets are composite materials presenting excellent wear resistance at room and high temperatures, together with high thermal shock resistance and thermal conductivity. These composites find preferential applications as tools for high-speed machining and finishing operations where they outer perform those of WC-Co hardmetals. Typical cermets compositions have Ti(CN) as main phase and Ni and/or Co as binder phase. The addition of secondary carbides is also used to increase the binder wettability and obtain a characteristic *core-rim* microstructure, therefore impacting the composite mechanical performance. Ti(CN) based compositions with Ni/Co binder and secondary carbides, as WC, Mo_2C and NbC were considered. The microstructural design of the Ti(CN) based cermets was simulated by the ThermoCalc software and experimentally verified by X-ray diffraction (XRD) and scanning electron microscopy (SEM) in compositions with addition of different secondary carbides.

Experimental & Results

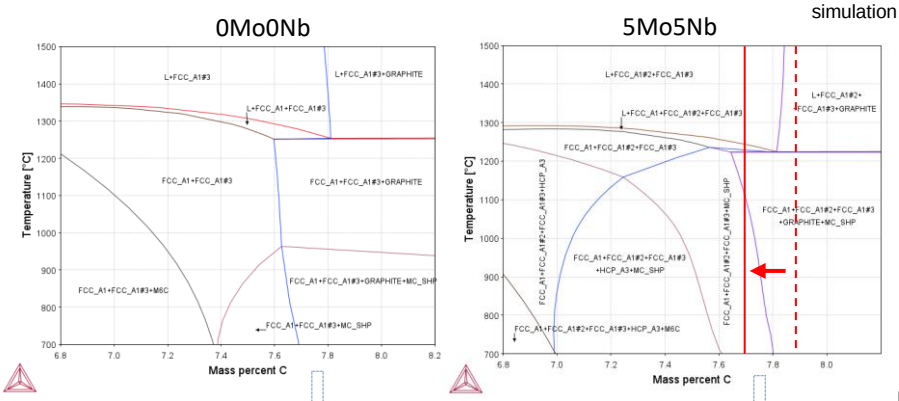
Composition (wt. %)	TiCN	WC	Ni	Co	Mo_2C	NbC
0Mo0Nb	67	18	7.5	7.5	0	0
5Mo5Nb	57	18	7.5	7.5	5	5



Phase diagrams simulation

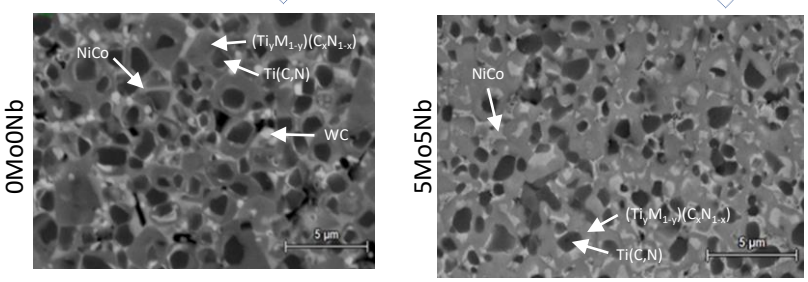
Sintering (SinterHIP - 1450 ºC , 60 min, 3 MPa)

Materials charaterization

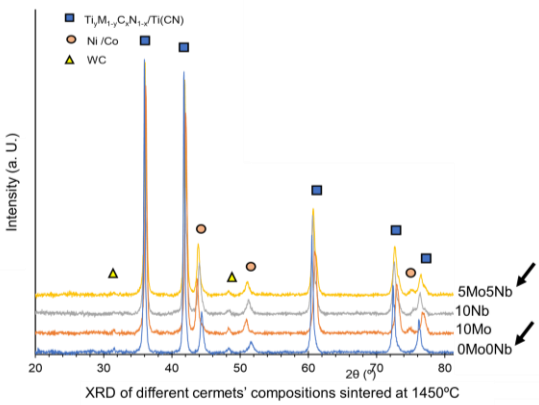


FCC_A1: NiCo
FCC_A1#2: $(Ti_yM_{1-y})(C_xN_{1-x})$
FCC_ A1#3: TiCN
MC_SHP: WC/MC
HCP_A3: M2C
M being W, Ti, Ni, Co, Mo, Nb.

Initial C — Final C (Leco analysis)



SEM micrographs after sintering at 1450ºC



XRD of different cermets' compositions sintered at 1450ºC

Conclusions

- XRD spectra of both compositions showed that, after sintered at 1450ºC, TiCN partially reacts with other carbides to form mixed carbonitrides, Ni is alloyed with Co and vestigial WC is detected, in accord with the thermodynamic calculations.
- SEM microstructures are typical of a liquid phase sintering presenting a TiCN core (black) and $(Ti_yM_{1-y})(C_xN_{1-x})$ rim phases (grey dark) surrounded by a NiCo phase, viscous at sintering temperatures, and traces of WC non-reacted phase. However, the microstructures are different, with a higher non-reacted TiCN content in the composition without Mo and Nb, which is coarser due to the more limited reaction effects.
- The initial carbon content was adjusted, based in the calculated phase diagrams, to compensate the losses during processing and position the sintered compositions in the region free of fragile phases, and a good accord was observed in terms of carbon window, as shown for the 5Mo5Nb composition .

References

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- C. M. Fernandes et al, Influence of secondary carbides on TiCN based cermets compositions, Proceedings – Euro PM2020.

Acknowledgments

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