Microwave sintering of cemented tungsten-cobalt carbides

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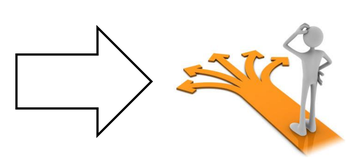
Context

Processing of WC-Co by powder metallurgy route: conventional sintering = vacuum sintering (VS).

Problem



Solution

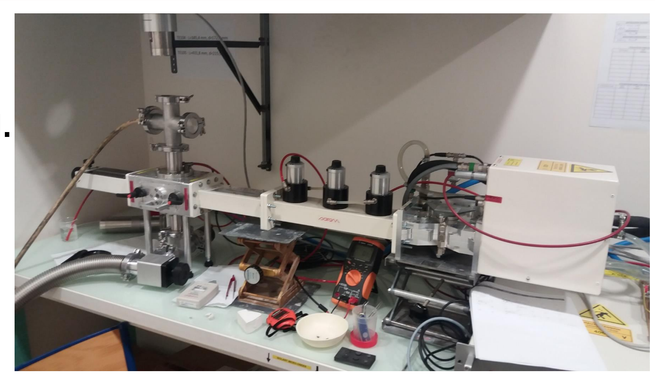
Grain growth due to high temperature, long holding times and low heating rates.
1400°C – 30 to 60 min – max. 5°C/min
Entire thermal cycle: 12 to 24 hours

Use of unconventional sintering technologies such as SPS, microwave sintering, flash sintering.
Goals: - Decreasing temperature and sintering time ↓
- Increasing heating rates. ↑

Material: Tungsten carbide with doped cobalt binder – 80% WC + 18% Co + 2% Cr_3C_2 (wt%)

Microwave sintering (MwS)

- Microwaves with 2.45 GHz.
- Single-mode cavity.
- Use of a susceptor → hybrid heating.
- Thermal and electrical contributions.
- Oscillations of free electrons in cobalt, of free carbon and ions in WC.
  → Different heating than VS.
- Time and energy saving!



Parameters

Pre-processing
- Balls diameters
- Compaction pressure

Sintering
- 1350°C and 1400°C
- 15 min sintering time
- 95% Ar – 5% H_2
- Heating rate: 75°C/min

Results and discussion

Name	Ball diameter (mm)	Cold Compaction Pressure (MPa)
VS1	12	500
VS2	12	200
VS3	10	500
VS4	10	200
MwS1	12	500
MwS2	12	200
MwS3	10	500
MwS4	10	200

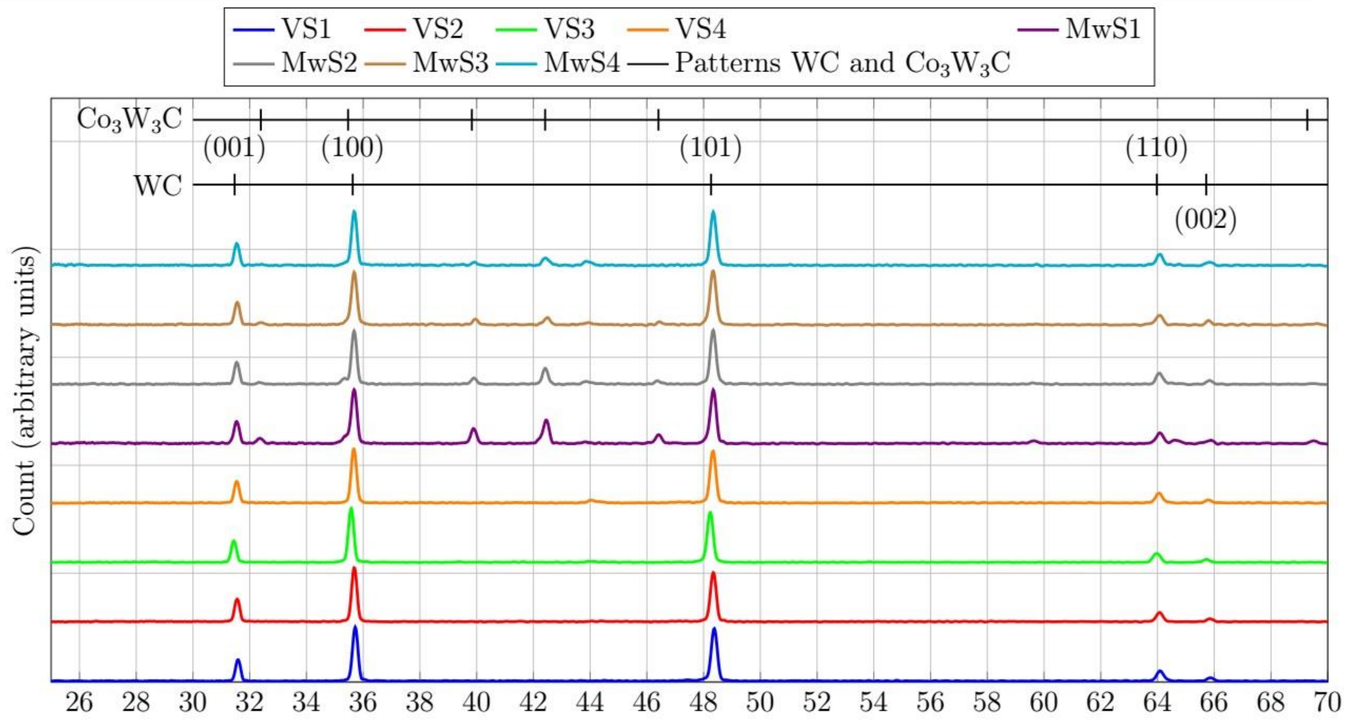
All samples sintered at 1400°C. Same behaviour at 1350°C but lower densities.

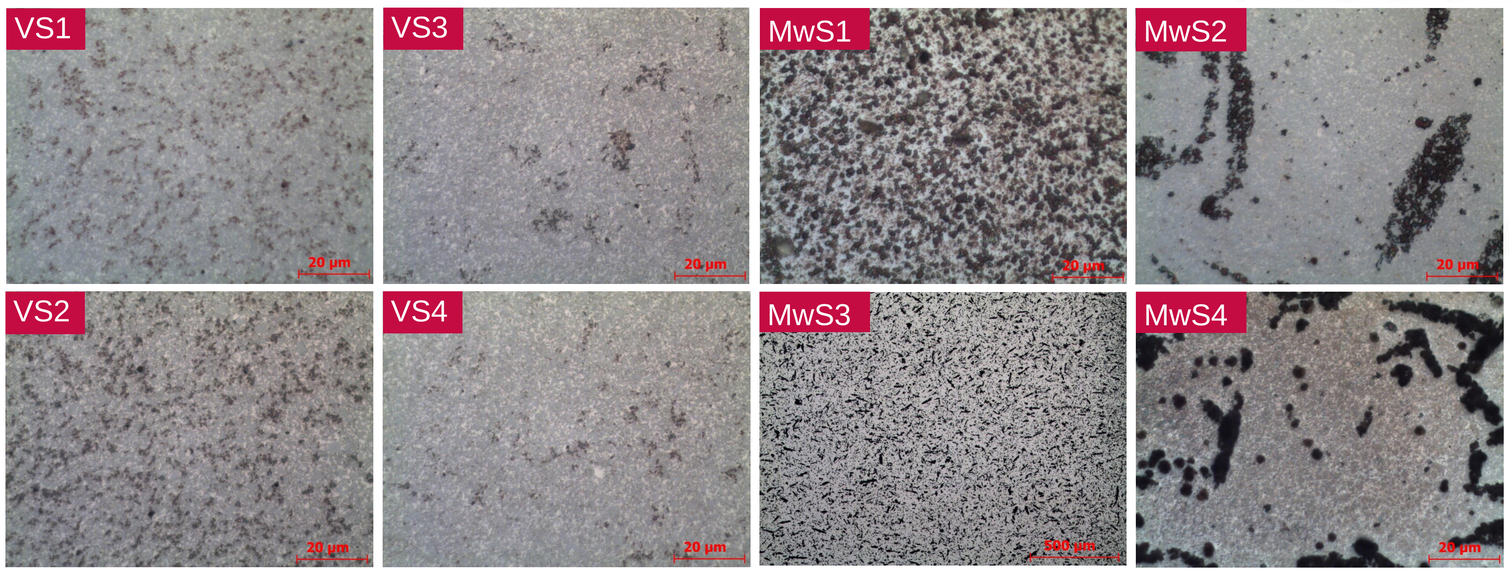
Different heating → microstructure variations.
- MwS: concentration of Cr_3C_2 (in black).
- VS: non homogeneous microstructure within the sample. Gray: WC and white: Co

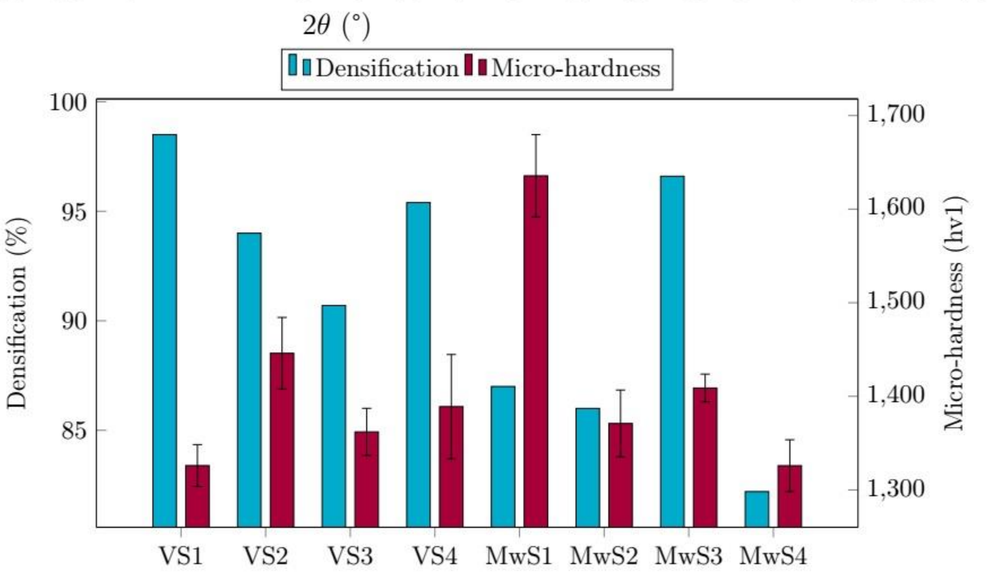
Presence of Co_3W_3C (brittle eta-phase) → Sign of decarburization (unwanted).

In general: higher densities for VS-samples but not really higher hardness.

However: many macro-cracks seen in MwS for all samples except MwS3.







Conclusion and perspectives

Microwave sintering = promising technology to manufacture WC-Co (energy and time saving).
→ Processing parameters must be improved and optimized.

Best parameters:
- Balls with 10 mm diameter: enhancement of the interactions between the powder and the balls.
- 500 MPa cold compaction pressure: higher densities and less brittle samples.
- Higher sintering temperature: higher densities.

Further improvements: elimination of decarburization and increase of the densities.

References

[1] Fang and al., Int. J. Refract. Met. H., vol. 27, pp 288-299, 2009.
[2] Stanciu and al., Proceedings METAL, Brno, 2014.
[3] Breval and al., Mater. Sci. Eng., vol. A391, pp 285-295, 2005.

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