

# Unconventional sintering of cemented WC-Co carbides

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## Context

Tungsten-cobalt carbides (WC-Co) are usually used in manufacturing (cutting tools, cutting inserts) and in mining industries. It was shown (Hall-Petch relationship) that decreasing grain size increases the mechanical properties such as hardness. Unfortunately, with the conventional sintering processes, a rapid grain growth is observed. The aim of the thesis is the study and the optimization of the unconventional sintering processes (in which grain growth is limited). These techniques are **SPS (spark plasma sintering)**, **microwave sintering**, **flash sintering** and **hot pressing**.

## Processing

### Raw materials: powders



WC + Co + Additives

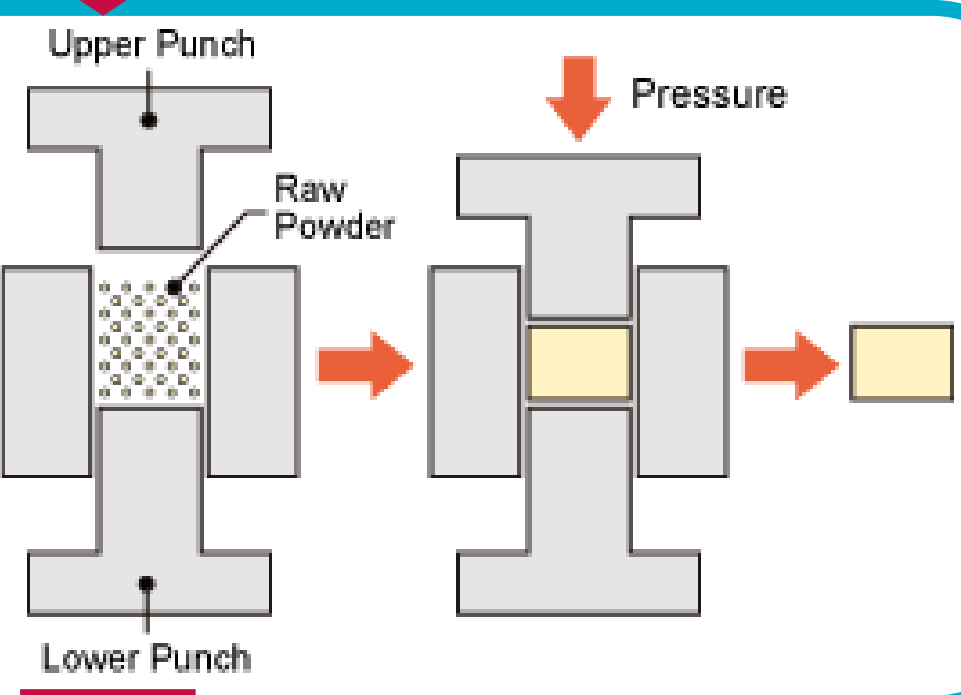
### Milling and Mixing

By ball milling



WC-Co powder

### Uniaxial cold pressing



## Sintering

### Metallurgical quality control

### Products ready to use

Cutting tools  
Cutting inserts  
Mining tools  
Construction tools.



## Acknowledgments

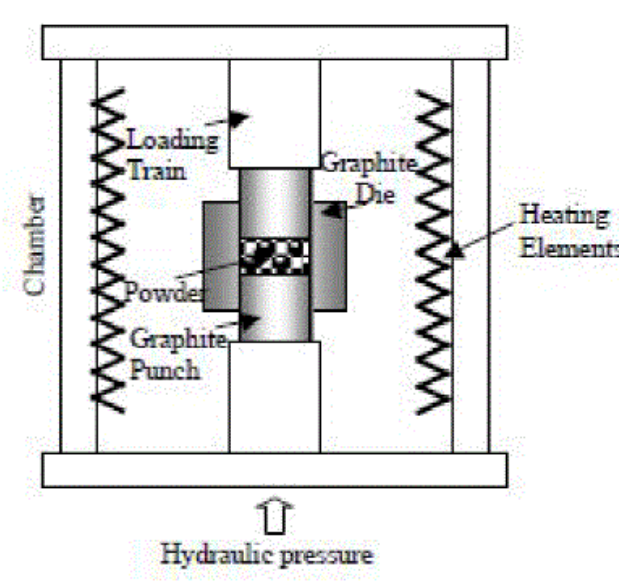
Acknowledgments to RWTH Aachen (SPS) and LMCPA Maubeuge (MwS) for their collaborations.

## Sintering

### Conventional sintering technologies

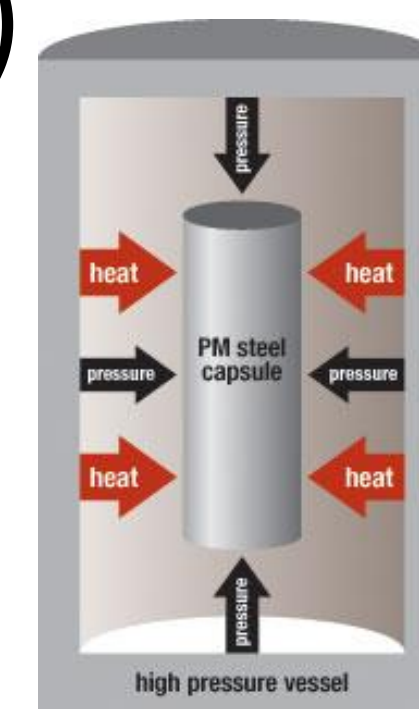
#### Vacuum Sintering (VS)

- > 1400°C
- 12 to 24h



#### Hot Isostatic Pressing (HIP)

- ~ 1000°C
- 1h
- ~ 150 MPa

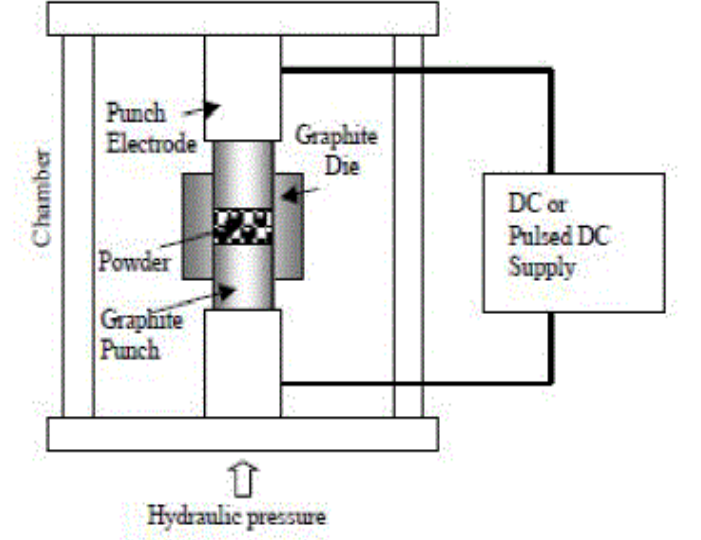


A rapid grain growth is observed, even with grain growth inhibitors.

### Non-conventional sintering technologies

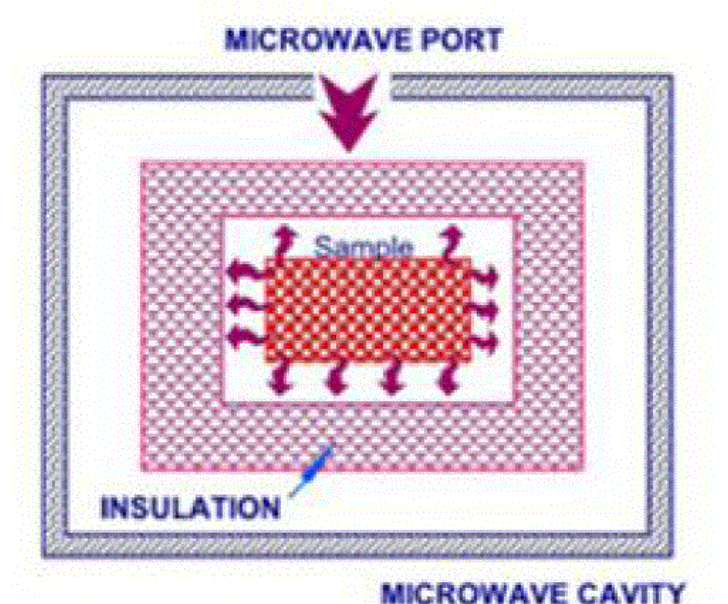
#### Spark Plasma Sintering (SPS)

- ~ 1100°C
- 5 to 10 min



#### Microwave sintering (MwS)

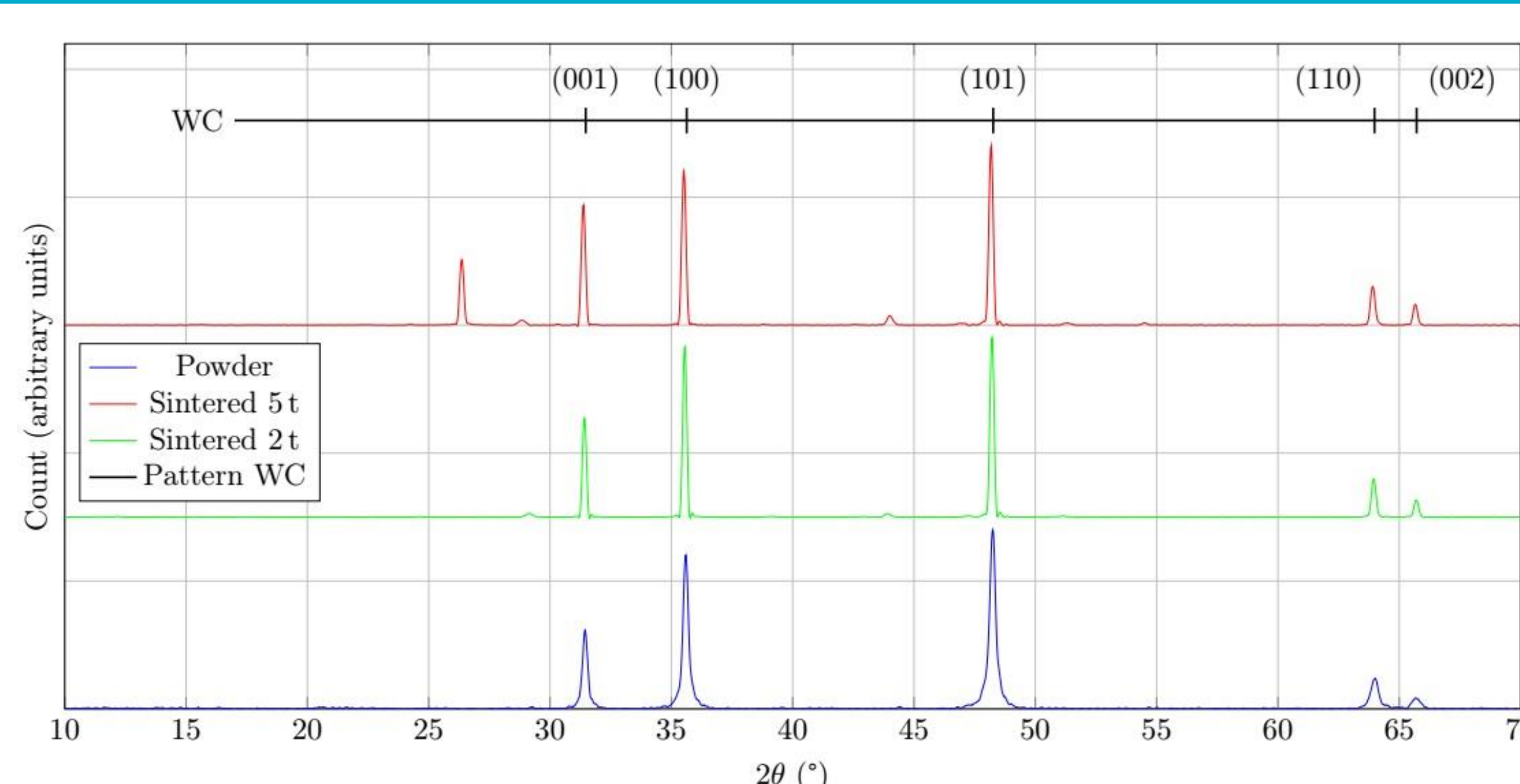
- ~ 1300°C
- 5 to 30 min



#### Flash Sintering (FS)

Hot Pressing (HP) → New Tech!

## Characterizations and first results

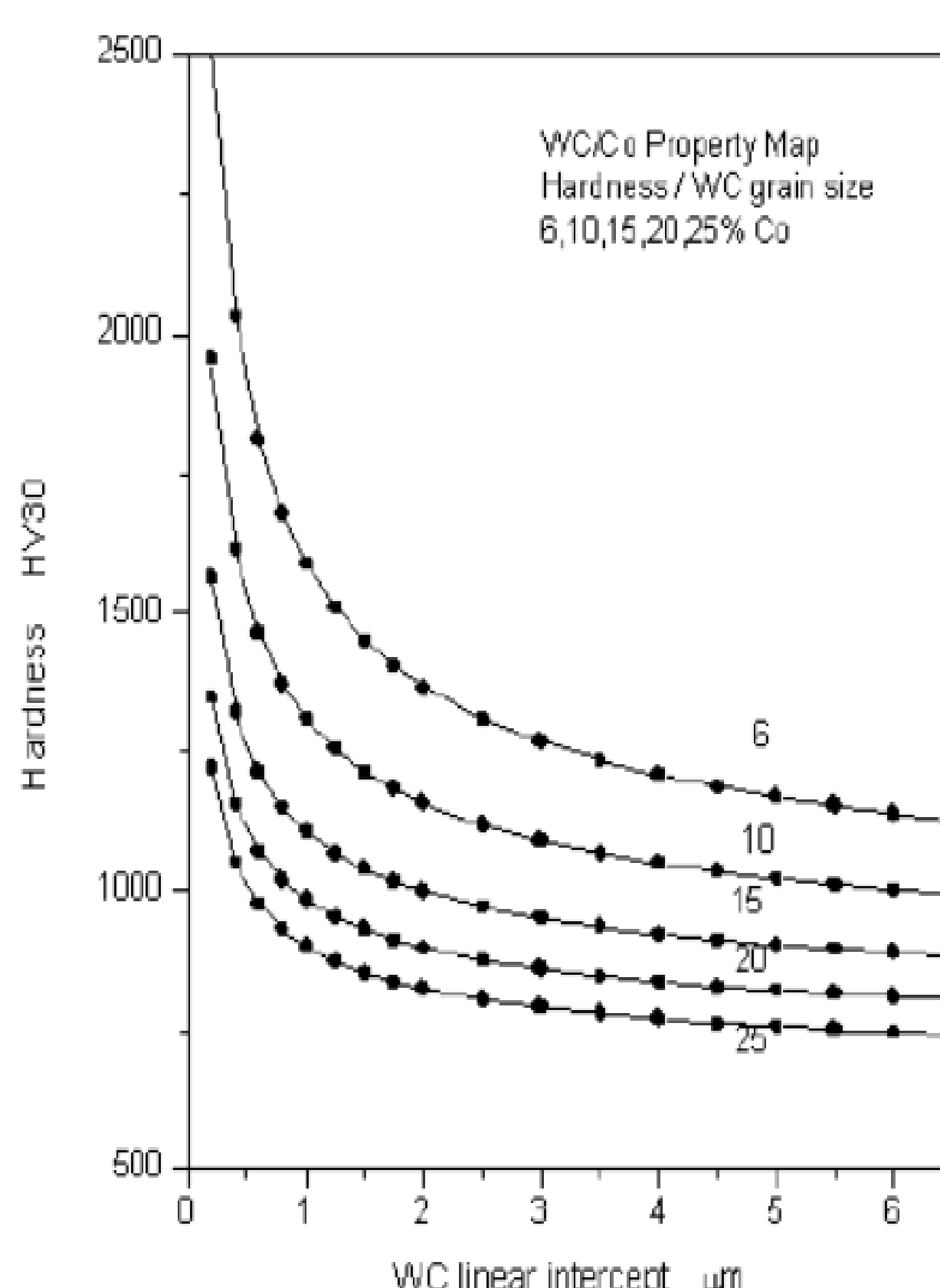


### X-ray diffraction (XRD)

- Control of the phases in the powder and in the sintered samples.
- Determination of the average crystallites size.

### Mechanical properties measurement

- Hardness: macro and micro-Vickers
- Toughness: Palmqvist relationship
- Wear tests



### Density measurement

- Control of the densification by Archimede's method.

### Microstructure observations

- Optical microscopy
- Scanning electron microscopy (SEM)

### SEM picture

