PRELIMINARY COMPARISON OF HARD METALS OBTAINED BY SPS AND BY ELECTRICAL RESISTANCE SINTERING (ERS)

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ABSTRACT

Cutting tools with improved properties and using a new processing method are being developed for both aerospace and automotive applications within **EFFIPRO**; **an EC granted project.** The aim of the project is to develop a new energy efficient sintering process for cutting tools production. This new method is based on Joule effect sintering process which allows extremely fast sintering cycles.

This work presents the preliminary results obtained within **EFFIPRO** using a novel sintering process (ERS: Electrical Resistance Sintering) and makes a comparison with conventional Sinter-HIP process and SPS process. The development of ERS process will allow the development of new or improved WC particulate composite cutting tool materials, offering an opportunity for innovative materials processing and property development along with potential commercial applications.

INTRODUCTION

Cemented carbides are usually produced by sintering with the participation of a liquid cobalt phase. However, the presence of this phase during the WC–Co sintering, stimulates the growth of the WC grains. Thus, the control of grain growth of the carbide phase during liquid phase sintering is an important objective.

In general, decreasing WC particle size increases mechanical properties such as hardness, wear resistance, and transverse rupture strength of the composites. Increasing the volume fraction of Co increases the fracture toughness at the expense of hardness and wear resistance. WC–cobalt and other similar cemented carbides are used as cutting tools because of a combination of desirable high hardness and high fracture toughness due to the respective contributions of the carbide and metallic phases.

The use of non-conventional sintering processes such as **ERS** (electrical resistance sintering) and SPS (spark plasma sintering) offers a unique opportunity to avoid the liquid phase sintering and thus limits the WC grain growth. During these fast sintering processes, the process time is substantially shortened and the sintering temperature may be reduced.

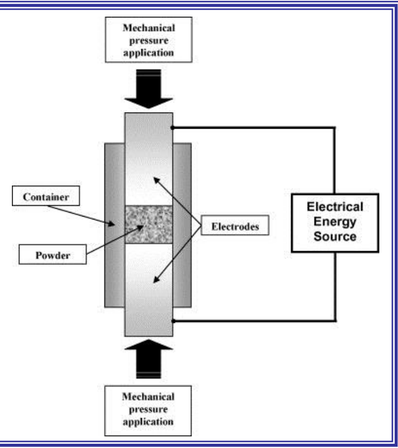
EXPERIMENTAL

Submicron size WC-6wt.%Co powder was sintered using three different routes and their properties were compared.

Route 1: Sinter-HIP: After pre-treatment the powder was dry pressed and sintered in a Sinter-HIP furnace at a temperature of 1400°C under an argon pressure of 8 MPa (80 bar) for 90 min.

Route 2: SPS: the powder was filled in a graphite die between two graphite punches. The compacts were fabricated by fast hot pressing using FCT-HP D 5/2 by FCT Systeme GmbH.

Route 3: ERS: powder was filled in a ceramic die between two electrodes (see figure). The whole process duration is a few seconds.



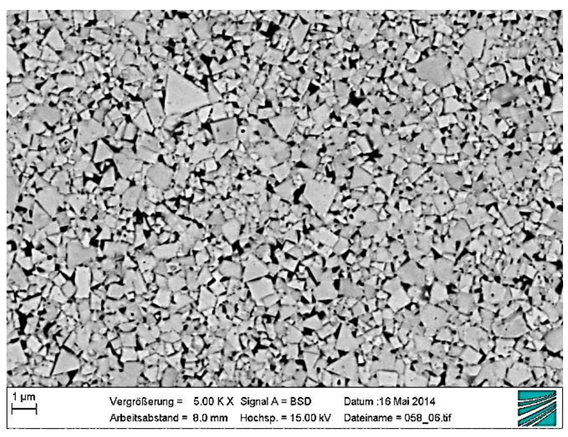
RESULTS AND DISCUSSION

Density:

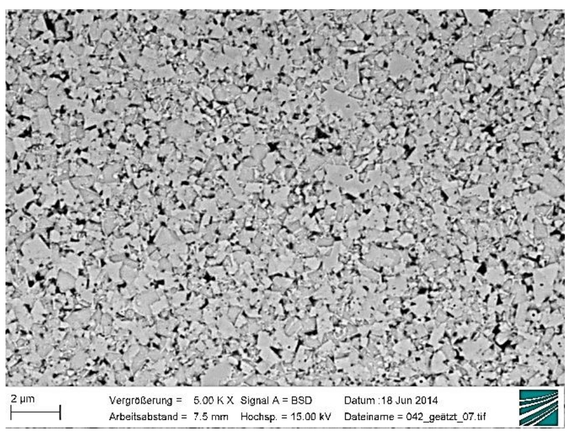
REF.	PROCESING	COMPOSITION	DENSITY (g/cm³)	% of the Theoretical Density
1	Sinter HIP	WC-6Co	14.88	100
2	SPS	WC-6Co	14.83	99.7
3	ERS	WC-6Co	14.80	99.5

The density obtained in the three processing routes has been very similar. The best values are shown by the commercial reference. Nevertheless, samples obtained using the alternative sintering methods show very high density as well, within typical required values for hard metals tools.

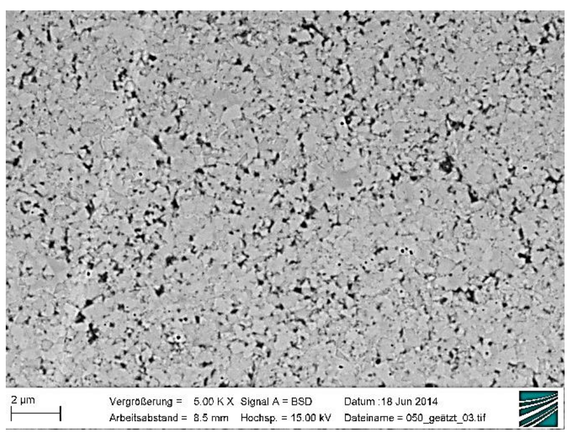
Microstructure:



WC6Co sinter-HIP



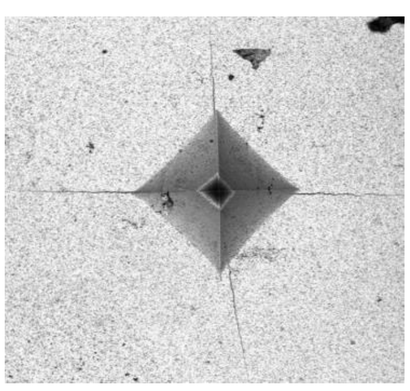
WC6Co SPS



WC6Co ERS

The microstructure obtained in the three routes is quite similar, polygonal WC grains can be appreciated surrounded by Co metallic matrix. Nevertheless, it seems to be a grain refining as the duration of the sintering process decreases, from the longer duration process to the shorter one: Sinter-hip, SPS and ERS. This confirms that the manufacturing process greatly influence the microstructure of the final part. In addition, the rapidly sintered samples show some AB-porosity less than 02.

Hardness & Fracture Toughness (K_{IC}):



REF.	PROCESING	COMPOSITION	Hardness (HV30)	K1C MPa√m
1	Sinter HIP	WC-6Co	1833	9.6
2	SPS	WC-6Co	1938	9.4
3	ERS	WC-6Co	2080	10

The very short processing time used in ERS (in the order of few seconds) helps in controlling the grain growth and thus obtaining finer microstructures. Although slightly lower densities are achieved with ERS process, it seems that the finer microstructure has an effect in improving the mechanical properties of WC-Co. The hardness as well as the fracture toughness gave better values than SPS or commercial references.

CONCLUSIONS

In this work the first results of the EFFIPRO project have been presented. The objective of this project is to develop a new very fast sintering method to produce cutting tools. Thanks to the short processing time, the novel sintering technology will enable, on the contrary to traditional furnace sintering methods based on thermal conduction and convection, an important energy consumption reduction and a fine control of material micro- and nanostructures.

Preliminary results regarding density, microstructure, hardness and fracture toughness were very encouraging: Using ERS it is possible to obtain materials with high density and enhanced hardness and fracture toughness compared to the commercial (Sinter-HIP) and SPS materials. Taking into account that in all cases the same raw materials were used, it is believed that this increase is linked with the short processing time and the obtained microstructure. Microstructural investigations reveal the retained finer structure in ERS samples compared to the commercial and SPS samples.

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