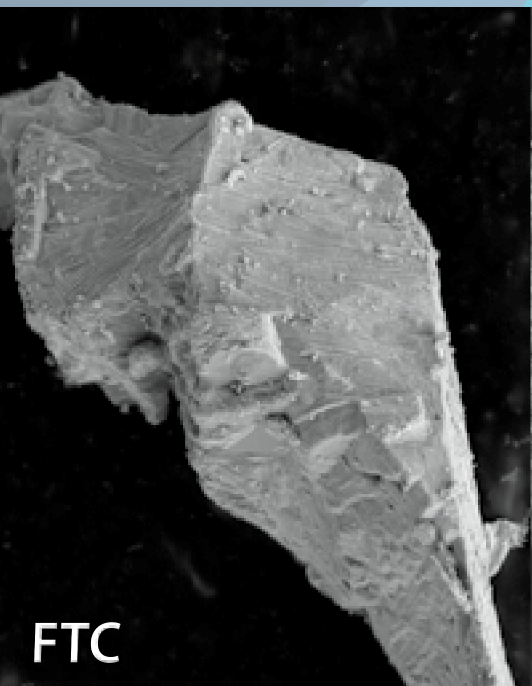
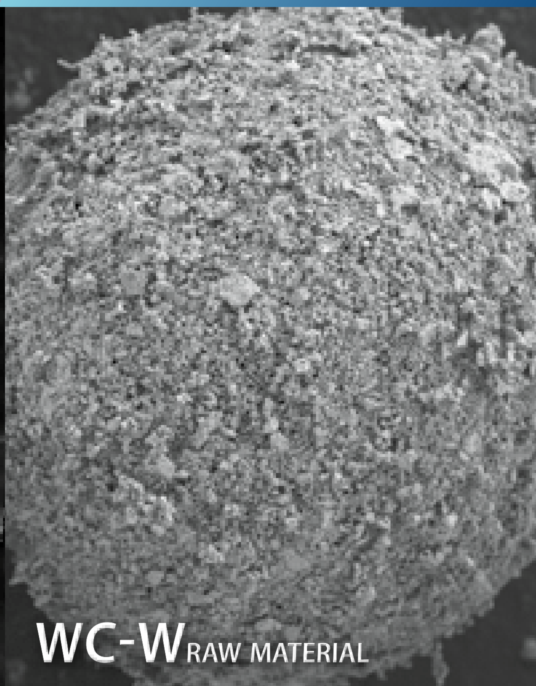
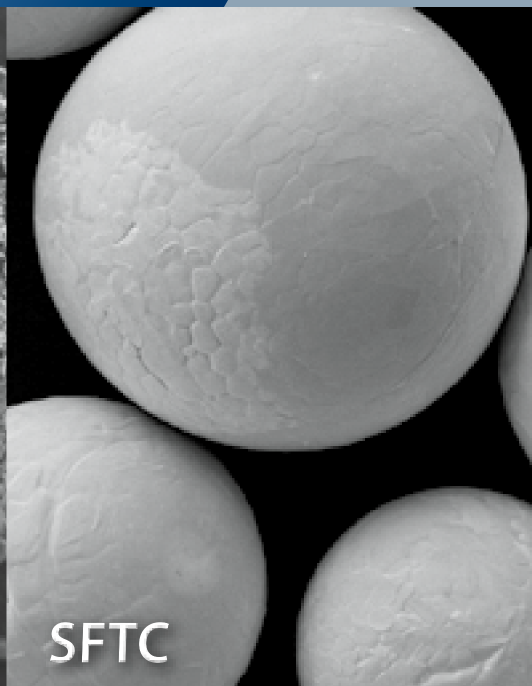
DURUM

VERSCHLEISS-SCHUTZ GMBH

QUALITY







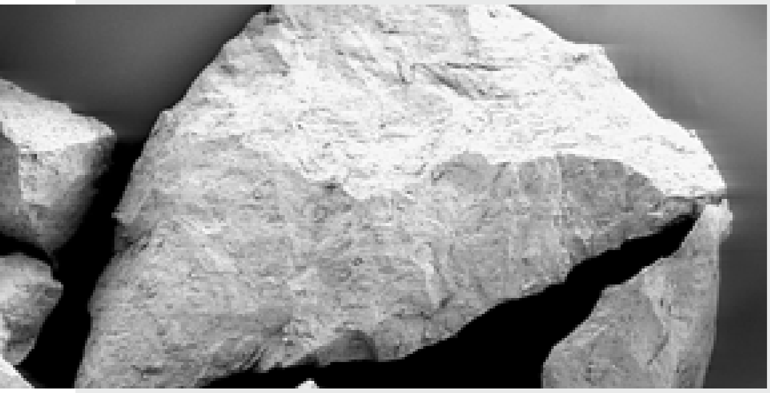
makes the DIFFERENCE

TÜV CERT

DIN EN ISO 9001:2008

DIN EN ISO 3834-3

DURMAT® FTC Powders



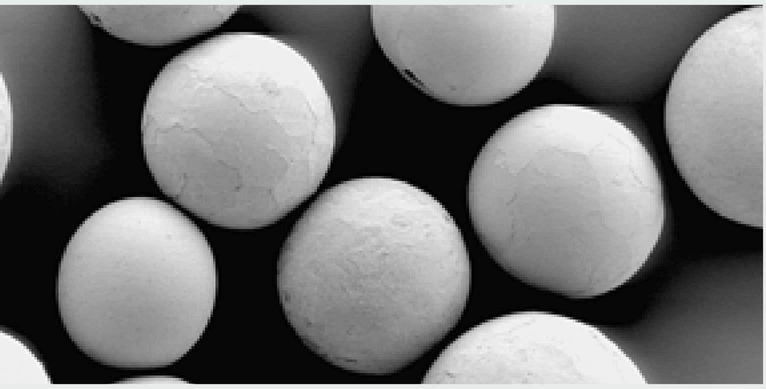
Fused Tungsten Carbide (FTC) is one of the hardest and most abrasion resistant materials used in modern wear resistance and tool technology.

FTC is the eutectic composition of WC and W_2C. The average carbon content of FTC is 3.8 – 4.1 wt. % and the phases can be estimated to be approximately 78 – 80% W_2C and 20 – 22% WC.

Application: hardfacing metallic surfaces exposed to extreme mechanical load. In this case FTC should be used as a fine or coarser powder, which is embedded in the metallic matrix or is precipitated into hard alloys (surface coating by thermal spraying or welding). Using powder metallurgical processes, it is possible to produce parts of nearly any shape, which can contain hard materials or diamonds together with a metal binder and FTC (reinforcing the hardness of diamond tools). FTC equalizes the matrices between the different hardnesses of diamonds and binder in diamond drilling, grinding and honing tools. Excellent for deep well drilling tools and rods, crusher jaws, mixers, concrete and stone saws, hot-pressed tools, screens & conveyors, extrusion housings, hard additives to diamond bits and saws.

Product		DURMAT® FTC	DURMAT® SFTC
Alloy type	-	$WC-W_2C$	$WC-W_2C$
Parameter	Unit	Typical data	Typical data
CTOTAL	%	3.8 - 4.1	3.8 - 4.1
CFREE	%	0.1 max.	0.1 max.
O_2 SIEVE RANGE	%	0.05 max.	0.05 max.
O_2 SUB SIEVE RANGE	%	0.2 max.	0.2 max.
Fe	%	0.3 max.	0.3 max.
Co	%	0.3 max.	0.3 max.
Hardness	HV	2,360	3,000
Structure	-	mainly feather	fine
Density	g/cm³	16 - 17	16 - 17
Melting point	°C/°F	2,860/5,176	2,860/5,176

DURMAT® Spherical Tungsten Carbide (SFTC) is the most wear resistant Fused Tungsten Carbide we can offer.



DURMAT® SFTC Powders

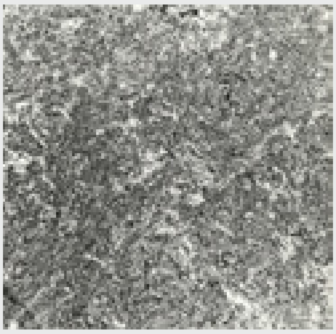
These SFTC spherical fused tungsten carbide particles show a fine non-acicular structure with a higher hardness than conventional FTC (>3,000 $HV_{0.1}$). The increased apparent density combined with a better flowability enable an increase of hard particles in wear resistant coatings and components produced by infiltration.

Using powder metallurgical processes, it is possible to produce parts of nearly any shape, which can contain hard materials or diamonds together with a metal binder and SFTC, reinforcing the hardness of diamond tools. FTC equalizes the matrices between the different hardnesses of diamonds and binder in diamond drilling, grinding and honing tools. Excellent for deep well drilling tools and rods, crusher jaws, mixers, concrete & stone saws, hot-pressed tools, screens & conveyors, extrusion housings and hard additives to diamond bits and saws.

Patent No.: US 6,428,600
Date of Patent: Aug. 6, 2002
EP 1 086 927

The constant testing of our raw materials, production and preshipment procedures ensure the homogeneity of the compliance with the specifications of all powder grades that we deliver.

DURMAT® - FUSED TUNGSTEN CARBIDE - FTC



Fused Tungsten Carbide (FTC), is an extremely hard, wear resistant material. Its abrasion resistance is superior in terms of wear resistance to all other commercially available materials except diamond. It is far superior to any of the chromium carbide products presently in use and will always deliver very positive test results by comparison. This material forms the basis of all DURUM's abrasion-resisting products.

Due to a special method of processing, in connection with a rapid cooling of the fused mass, the carbide solidifies in a "feather" structure. The top figure shows a superior quality FTC with a "fine-feathered" structure, whereas the lower figure shows an inferior FTC with an acicular and block shaped structure, which is unsuitable for wear protection.

The properties of the FTC are very much dependent on it's structure. An FTC that demonstrates at least an 80% "feather" structure has a macro-hardness of approximately 2,000 HV_{30}. The micro-hardness of this material has been measured at 2,300 - 2,500 $HV_{0.1}$.

FTC has a carbon content of 3.8-4.1%. This corresponds to a ratio of 78 - 80% FTC and 20- 22% WC. Careful attention must be paid during the processing and application of products containing FTC, that the temperature does not exceed 1,800 degrees C. Higher temperatures would cause an alteration in the structure resulting in a loss of hardness. If this excessive overheating occurs during the welding procedure, an unproportionately high amount of FTC will be dissolved in the iron matrix, which would also result in a reduction of the material's superior ability to resist wear.

The correct selection of grain shape, size and distribution is of utmost importance with all FTC products. Use of grain sizes, between 0.063-0.7 mm, provide the best results for protection against wear and tear. Larger grain sizes, between 0.7 -1.2 mm, are chosen for cutting tools.

DURUM also ensures scientifically ascertained 'best grain distribution'. A sharp-edged grain is superior for cutting tools. A rounded or spherical grain is better suited for wear protection -as sharper edges tend to wear down much quicker. DURMAT products are also offered with spherical shaped FTC for the prevention of extreme abrasive wear.

Ore $\xrightarrow{\text{Mechanical and thermical treatment}}$ APT $\xrightarrow{\text{Reduction}}$ W-metal $\xrightarrow[\text{approx. 2,000°C}]{\text{Carburization}}$ WC

WC + W-metal $\xrightarrow[\text{approx. 2,700°C}]{\text{Fusing}}$ FTC

FTC ingot $\xrightarrow{\text{Crushing}}$ FTC powder

W-C binary phase diagram

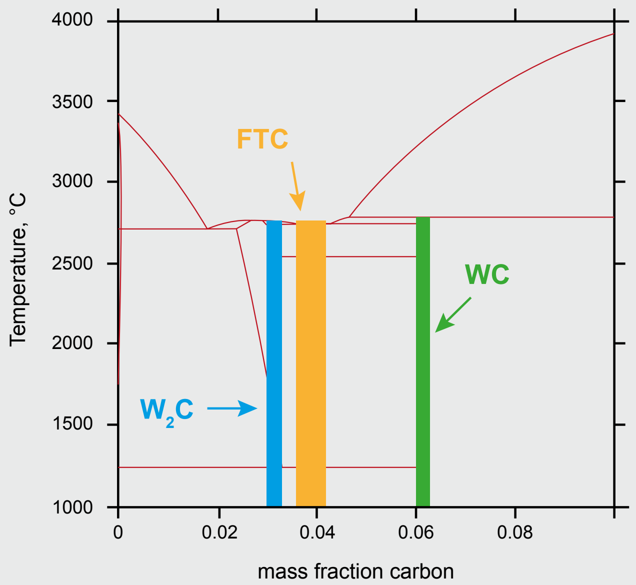
WC 6.13 %C
Hardness ≈ 2,000-2,400 $HV_{0.1}$

W_2C 3.2 %C, very brittle

FTC (fused tungsten carbide)
eutectic mixture consisting out of:
- ≈20–22% WC
- ≈78–80% W_2C in a lamellar shape (feather-like)
- ≈ 3.8 – 4.1 %C, T_M ≈ 2,650 °C

Hardness ≈ 2,200 – 2,500 $HV_{0.1}$

SFTC (spherical fused tungsten carbide)
Hardness ≈ 3,000 $HV_{0,1}$



Different forms of Tungsten

Oxidized SFTC

SFTC

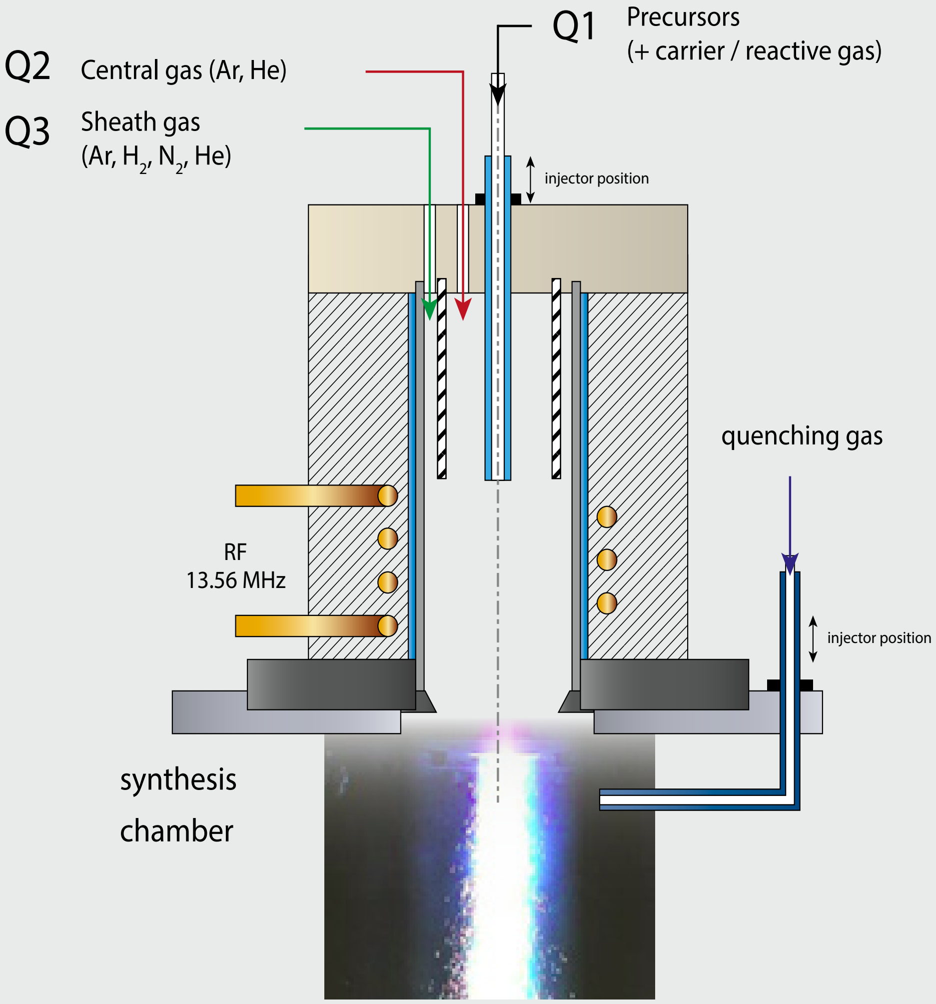
(nano) WO_2

FTC

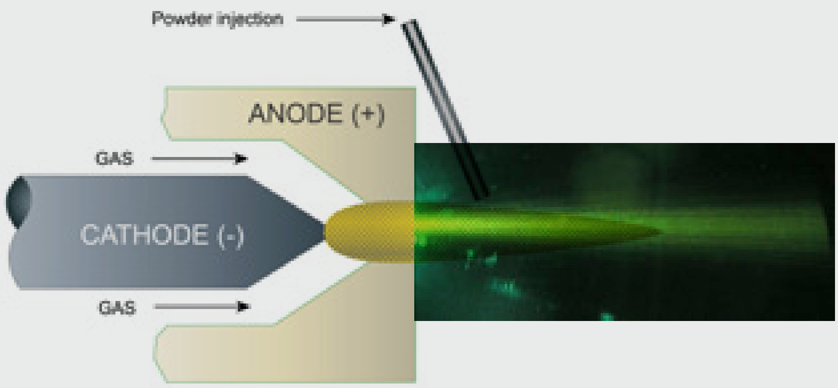
(nano) WO_3

SFTC synthesis

HF-Plasma



DC-Plasma

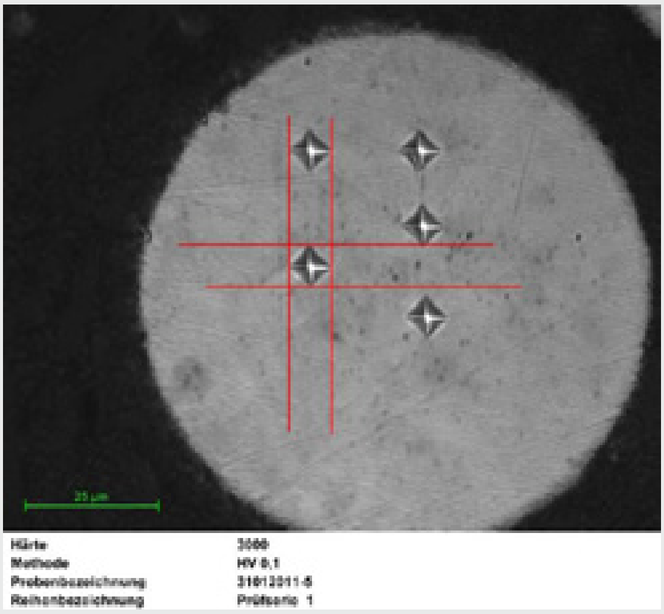


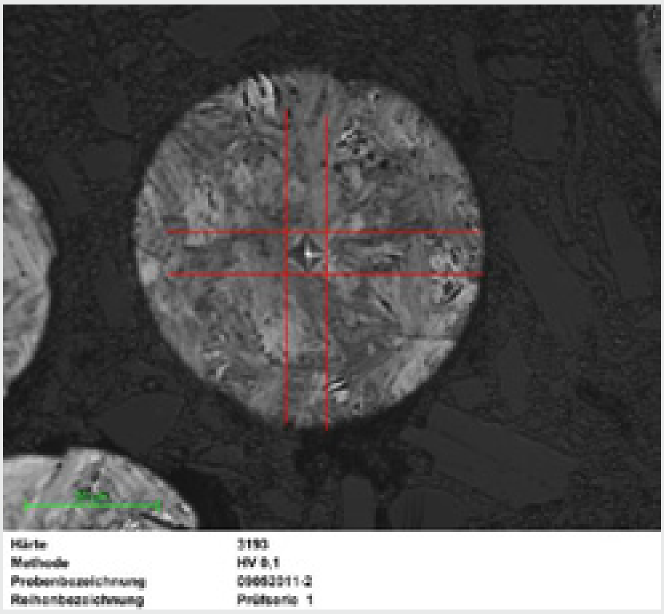
Sample preparation and analysis

- Optical microscopy
- Hardness measurements
- X-Ray Diffraction (XRD)
- High resolution scanning electron microscopy (HR-SEM)
    - images
    - energy dispersive diffraction (EDX)
- Particle size measurements
    - Microtrac
    - powdershape

Vicker´s Hardness

Indentation with diamond pyramid





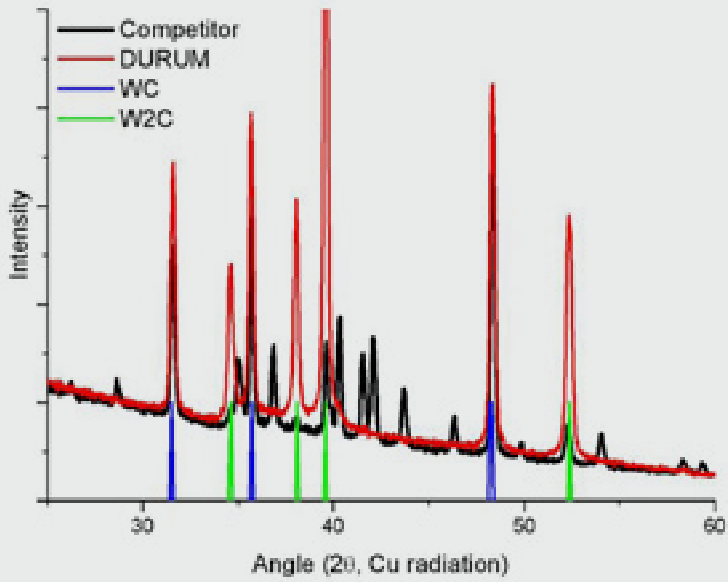
XRD measurements

X-ray diffraction for determination of the global phase composition

Non-marked peaks:

Black: FeWC

($Fe_{3.57}W_{9.43}C_{3.54}$)

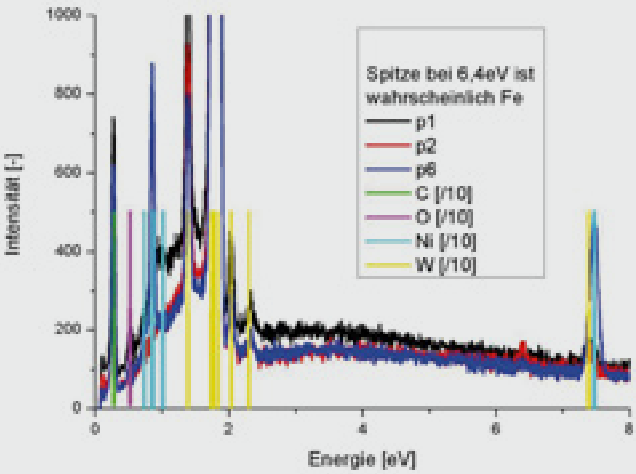


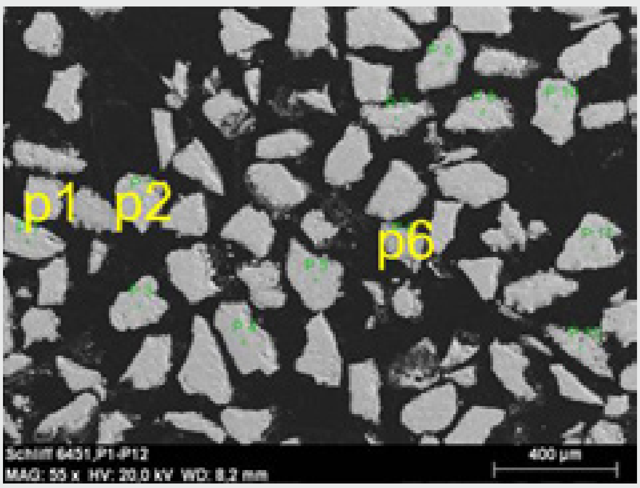
EDX-measurements

Energy dispersive X-ray measurements for element analysis

Useful for detection of possible contamination by determination of local chemical composition

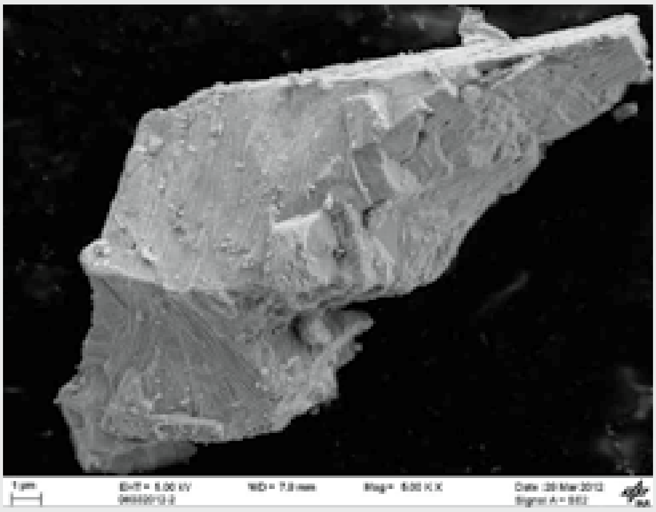
Presence of Ni in the FTC powder

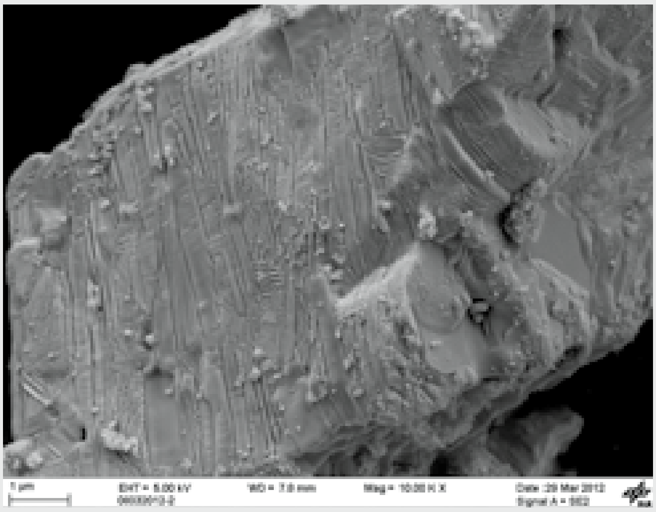




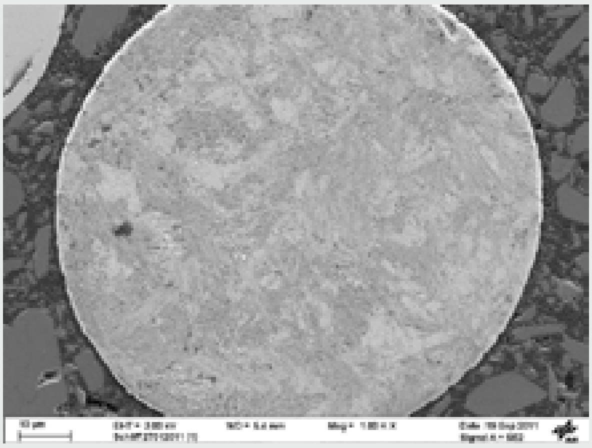
HR-SEM

High resolution Scanning electron microscopy for determination of particle shape and surface

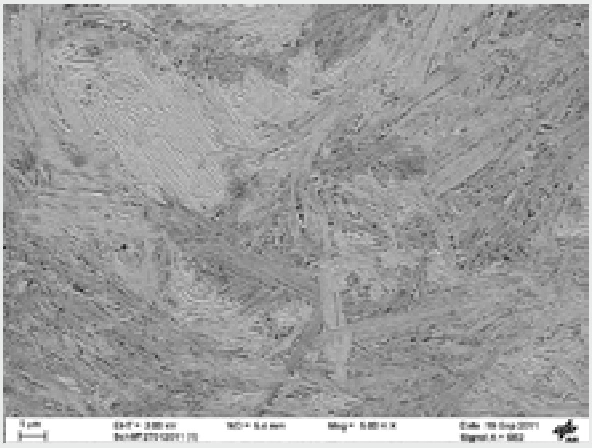




Determination of micro- and nanostructure

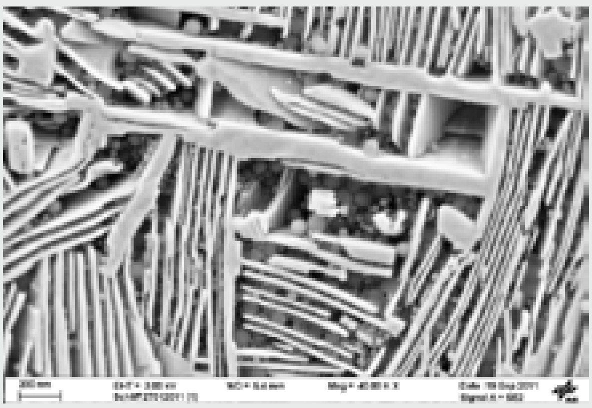


Magnification: 1,000x



Magnification: 5,000x

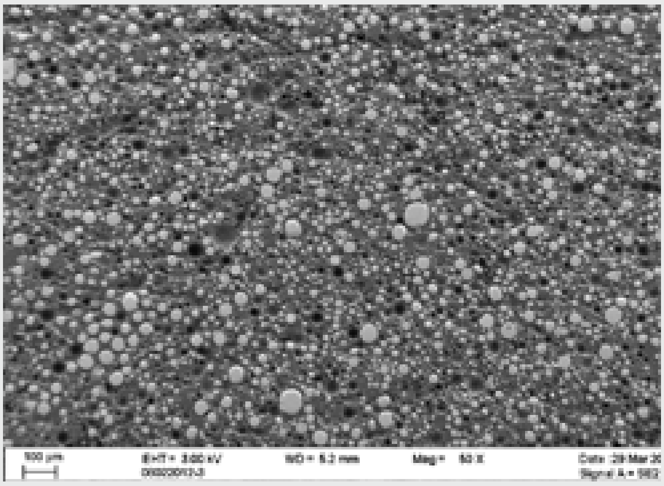
Magnification: 40,000x

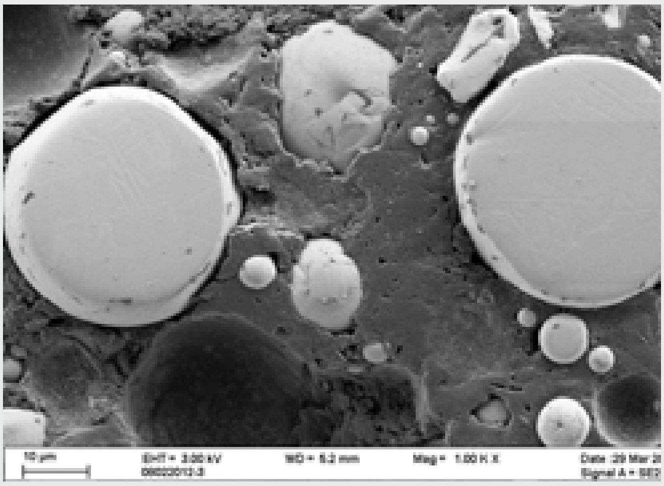


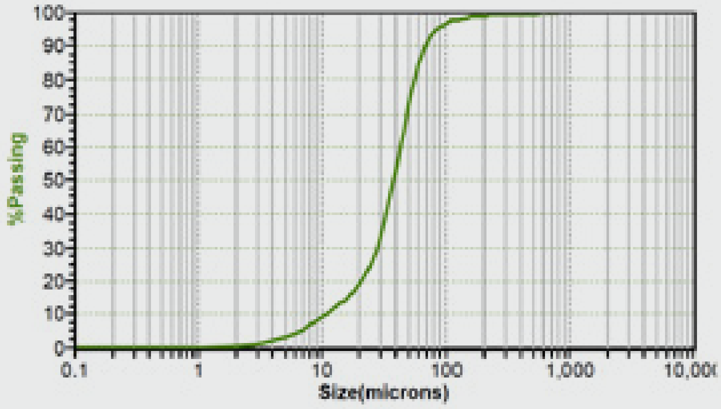
Spheres are polishing material

Small SFTC

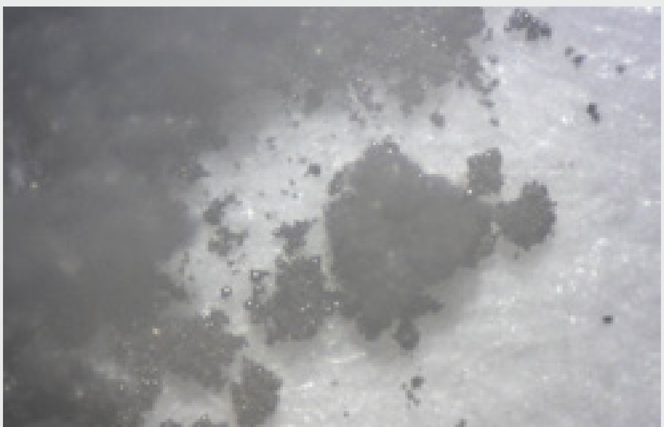
SEM images of fine SFTC embedded in a polymer. Particles removed by sample preparation appear as holes.



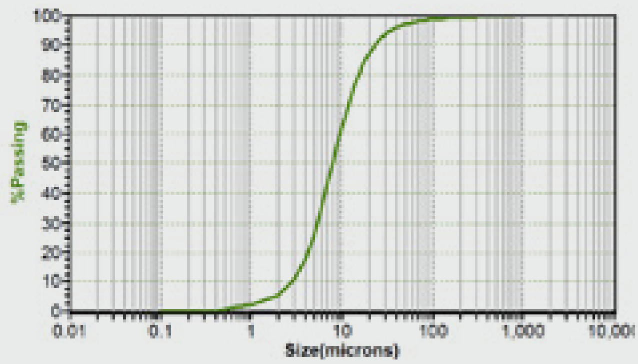




Very fine SFTC



Width image 950µm

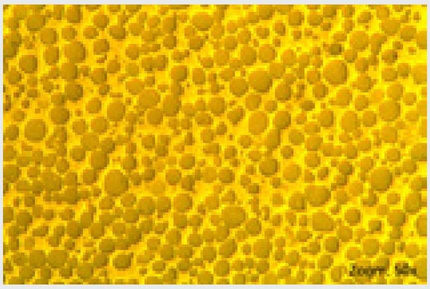


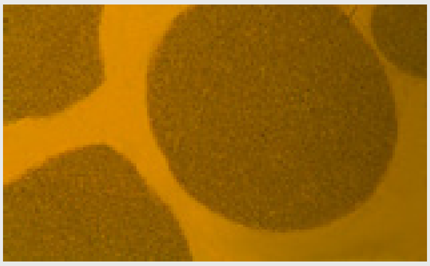
Tungsten Carbide and its Derivatives

Thanks to their outstanding strength properties, hardfacing alloys based on tungsten carbide (WC) and cobalt take a central position in wear protection. The high demands, which are placed on the wear resistance of such alloys these days, have led to increasingly finer micro structures with optimized compositions, allowing improved, higher performance alloys to be achieved.

The development of the thermal spray powders **DURMAT® 125** and **DURMAT® 135** represented our first steps in this direction. Their characteristic, fine-structured composition with crystallite grain sizes of max. 400 nm is their trademark and a guarantee for high wear resistance. We have also achieved comparable wear resistances in the powder cladding field using PTA or laser methods, by making the WC structure smaller in a similar way. Our **DURMAT® DNK 1.3** development using fine-structured WC thus resulted in hardness in the region of 1,750 $HV_{0.5}$. In an effort to establish a uniform parlance for identifying alloy structures, the German-speaking carbide industry has agreed on the following definitions to describe grain size categories. It is generally accepted at present.

Grain Size in µm						
<0.2	0.2 - 0.5	0.5 - 0.8	0.8 - 1.3	1.3 - 2.5	2.5 - 6	>6
nano	ultrafine	submicron	fine	medium	coarse	extra coarse





1. Abrasive wear

The greater hardness of the nano-scale hardfacing alloy associated with the decreasing WC grain size reduces wear from abrasion considerably. The harder "hardmetal" counters abrasion with a greater resistance.

Wear progresses significantly slower, as the binding metal layer between the fine grain hardfacing crystallites is exceptionally thin, making it harder to wash out. Due to this structural attribute, only very small hardfacing particles are torn out of the structural bond.

The spherical shape represents a further form of protection, which is further stabilized by the small grain size; small particles have to expend a great deal more energy to divide and become smaller than coarse ones.

2. Corrosive wear

A characteristic, higher wear resistance also occurs with regard to corrosive wear. As a result of the nano-structure and in particular the significantly reduced intermediate binding metal layer, the corrosive media can only reach the cobalt with difficulty, leading to considerable delays in wear. In turn, only the smallest hardfacing particles escape, corrosion is slowed down considerably.

As in most applications, abrasive and corrosive wear are barely distinguishable, due to the improvement in properties that can be achieved, a nano-structured carbide like **DURMAT® DN 3.0** is the better choice for both forms of wear.

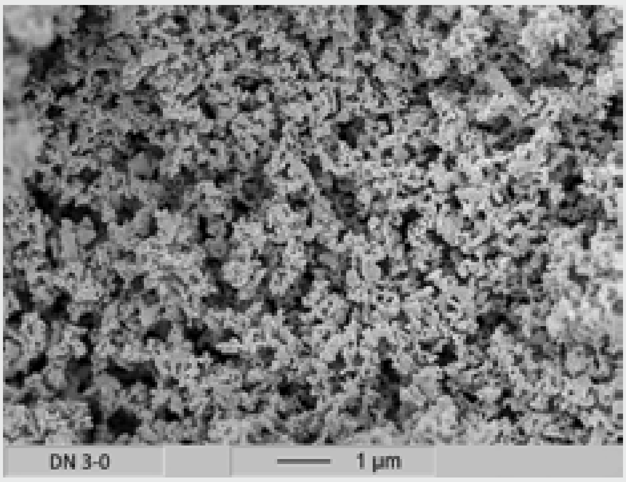
DURMAT® WC-Co Powders

Hardness: In WC-Co alloys of the same chemical composition, the hardness is mostly determined by the grain size of the carbide phase, which in turn depends on the primary grain size of the starting powder. When the grain size drops, the hardness increases considerably, meaning that a significantly high hardness level can be reached with the finest starting powders. The increase in hardness is always accompanied by the rise in coercive field strength.

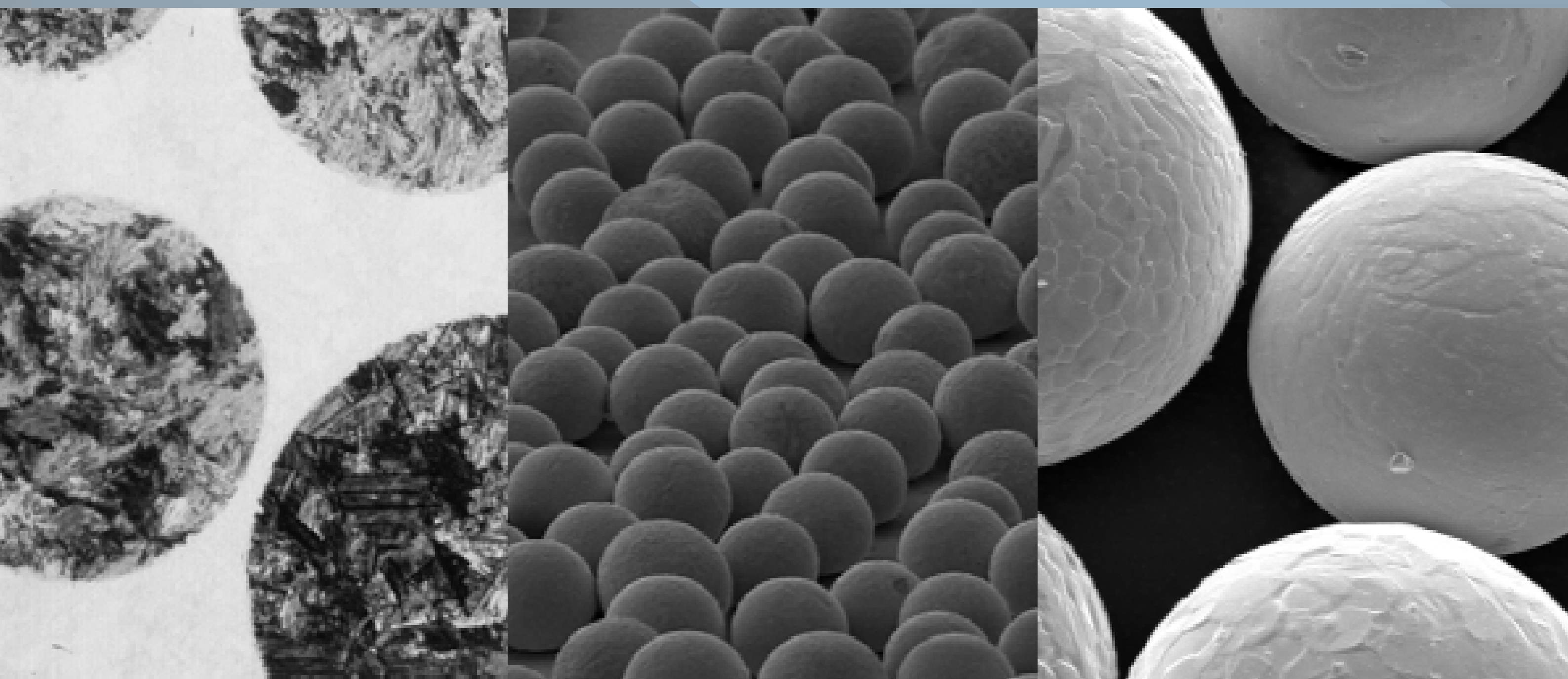
High temperature hardness: With increased grain fineness, these alloys also feature improved hardness properties at high temperatures, so that strength benefits emerge in high-temperature use particularly for wear protection layers made from them. The nano-scale WC raises the strength level a stage higher.

Toughness: A smaller grain size in the carbide phase with the same Co content results in a decrease in the distance between WC grains and hence to a reduction in particle movement.

Compressive strength: The high compressive strength of these carbide alloys is one of the most important properties in these materials, as it is significant in practically all technical applications. After diamond, hardmetal (cemented tungsten carbide) is the most pressure resistant material. This property is also of predominant significance in wear protection. The increase in the microstructure leads to a significant rise and as a result these nano tungsten carbides have the highest compressive strength.



Product DURMAT®	-	DN 3.0	DNK 1.3
Alloy type	-	WC-8Co	WC-Co
Parameter	Unit	Typical Data	Typical Data
Co	%	7.5 - 8.5	6 - 7
C_{TOTAL}	%	< 5.7	< 5.65
Fe	%	< 0.25	< 0.25
Ti	%	< 0.04	< 0.04
Mo+Nb+Ta	%	< 0.4	< 0.4
Others	%	bal.	bal.
Hardness	HV	2,400 - 2,550	1,950 - 2,050
Density	g/cm³	14.2 - 14.5	14.7 - 14.9
Apparent density	g/cm³	> 8.5	> 8
η-Phase	%	< 1	< 1
Microporosity	<6%	<A04/B02/C02	<A04/B02/C00
Binder lakes: >25µm	%	<6	<6
Binder lakes: >50µm	%	0	0
Cavities: >25µm	%	<6	<6
Cavities: >75µm	%	0	0
Grain Size	µm	45 - 300	45 - 250
Coercive field strength	kA/m	> 36	> 18
Magnetic saturation	µTm³/kg	13.7	11
Saturation percentage	%	88 - 98	> 92



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