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(54) Title: CERMET

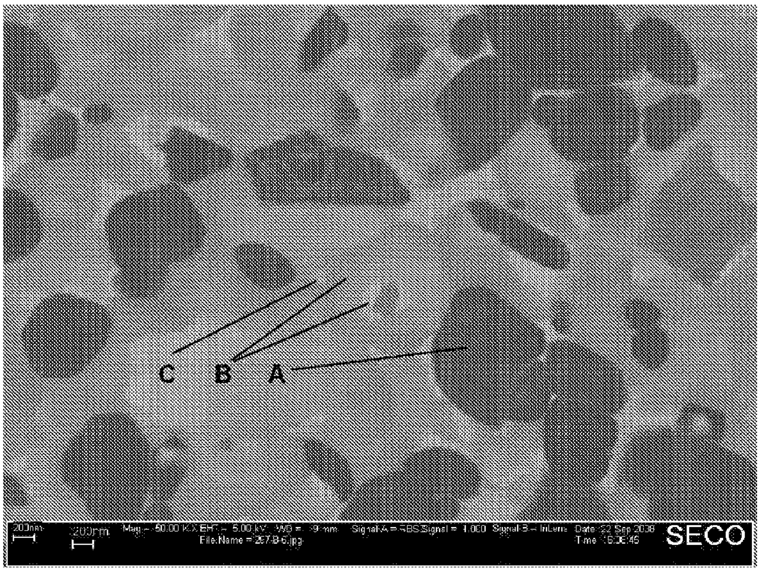

Figure 1.

(57) Abstract: The present invention relates to a titanium based carbonitride alloy containing Ti, Nb, Ta, W, C, N and Co. The alloy contains - Co 7 to 21 wt % - W 14 to 20 wt % - Ta 5 to 11 wt % - Nb 2 to 7 wt % and, - Ti 33 to 50 wt % whereby the overall N/C weight ratio is 0.6 to 0.75, the Ta/Nb weight ratio 1.8 to 2.1, the relative saturation magnetization 0.60 to 0.90 and the magnetic coercivity Hc= (18.2-0.2*Co wt%) +/- E kA/m, where E is 2.0. The invention also relates to a method of making said alloy.

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Cermet

The present invention relates to a sintered carbonitride alloy with Ti as main component and a cobalt binder phase, which has improved properties particularly when used as tool material for steel and cast iron cutting. More particularly, the present invention relates to a carbonitride-based alloy of specific composition and controlled relative saturation magnetization and coercivity for optimal combination of abrasive wear resistance, toughness and resistance to plastic deformation.

Titanium-based carbonitride alloys, so called cermets, are widely used for metal cutting purposes. Compared to WC-Co based materials, cermets have excellent chemical stability when in contact with hot steel, even if it is uncoated, but have substantially lower toughness. This makes them most suited for finishing operations, which generally are characterized by limited mechanical loads on the cutting edge and a high surface finish requirement on the finished component.

Cermets comprise carbonitride hard constituents embedded in a metallic binder phase generally of Co and/or Ni. The hard constituent grains generally have a complex structure with a core, most often surrounded by one or more rims of other composition. In addition to Ti, group VIa elements, normally both Mo and W, are added to facilitate wetting between binder and hard constituents and to strengthen the binder phase by means of solution hardening. One or more of group IVa and/or Va elements, e.g. Zr, Hf, V, Nb and Ta, are also added in all commercial alloys available today. Cermets are produced using powder metallurgical methods. Powders forming binder phase and powders forming hard constituents are mixed, pressed and sintered.

During recent years many attempts have been made to control the main properties of cermets in cutting tool applications, namely toughness, wear resistance and plastic deformation resistance. Much work has been done especially regarding the chemistry of the binder phase

US 6,344,170, US 6,344,445 and US 6,325,838 relate to a sintered body of a carbonitride alloy with titanium as main component with improved properties when used as cutting tool material. This has been achieved by combining a carbonitride based hard phase of specific chemical composition with an extremely solution hardened

Co binder phase. By optimizing composition and sintering process in the Ti-Ta-W-C-N-Co system improved toughness and resistance to plastic deformation are accomplished. The two parameters that are used to optimize toughness and resistance to plastic deformation are the Ta- and Co-contents. The use of pure Co-based binder is a major advantage over mixed Co-Ni-based binders with respect to the toughness behavior due to the differences in solution hardening between Co and Ni.

US 7,332,122, and US 7,157,044 are similar. They relate to a titanium based carbonitride alloy containing Ti, Nb, W, C, N and Co. By replacing Ta in US 6,344,170 by Nb and carefully controlling the amount of undissolved Ti(C,N) cores a further optimization of technological properties has been achieved. More particularly, said patents relate to a carbonitride-based hard phase of specific composition, for which the amount of undissolved Ti(C,N) cores is optimized for maximal abrasive wear resistance, while the Co and Nb contents are simultaneously optimized to give the desired toughness and resistance to plastic deformation.

It is an object of the present invention to design and produce a cermet material with specific composition and controlled relative saturation magnetization and coercivity for optimal combination of abrasive wear resistance, toughness and resistance to plastic deformation.

This has been achieved by working with the alloy system Ti-Ta-Nb-W-C-N-Co. A set of limitations has been found rendering optimum combination of abrasive wear resistance, toughness and resistance to plastic deformation for the intended application areas.

Fig. 1 shows the microstructure in detail and Fig. 2 shows the microstructure in a lower magnification of an alloy according to the invention as observed in back scattering mode in a scanning electron microscope in which

A depicts undissolved Ti(C,N)-cores

B depicts a complex carbonitride phase sometimes surrounding the A-cores and

C depicts the Co binder phase.

According to the present invention it has unexpectedly been found that optimum combination of abrasive wear resistance, toughness, resistance to plastic deformation and work piece surface finish for the intended application area has been achieved by optimizing the amount of carbo-nitride formers dissolved in the Co based binder, the ratio between Ta and Nb and the hard constituent grain size. The content of dissolved carbo-nitride formers in the binder phase may be expressed by the S-value, the magnetic saturation of the sample divided by the magnetic saturation of the same amount of pure Co as in the sample. The S-value depends on the content of dissolved metals in the binder phase and increases with decreasing amount of solutes. The sintered grain size of the hard constituents may be expressed by the magnetic coercivity.

The Co content must be chosen to give the desired properties for the envisioned application area. This is best achieved by a Co content of 7 to 21 wt%. In a first embodiment the Co-content is 8 to 15 wt% and, particularly, for fine machining applications the Co content must be 8 to 10 wt% and for applications requiring balanced resistance to plastic deformation and toughness 12 to 15 wt%. In a second embodiment requiring higher toughness the preferred Co content is 15 to 20 wt%.

The W content must be 14 to 22 wt%, preferably 16 to 19 wt%.

The Ta content must be 5 to 11 wt%, preferably 6 to 9 wt%.

The Nb content must be 2 to 7 wt%, preferably 3 to 5 wt%.

The Ti content must be 33 to 50 wt%, preferably 37 to 47 wt%.

The ratio between added Ta wt% and Nb wt% must be 1.8 to 2.1.

The overall N/C weight ratio in the sintered alloy must be in the range 0.6 to 0.75.

The C content must be adjusted such that the relative saturation magnetization is within 0.60 to 0.90, preferably 0.65 to 0.80.

The average grain size expressed by the magnetic coercivity depends on the amount of Co added and must be Hc=(18.2-0.2*Co w%) +/- E kA/m, where E is 2.0, preferably 1.5, and most preferably 1.0.

For certain machining operations requiring even higher wear resistance it is advantageous to coat the body of the present invention with a thin wear resistant coating using PVD, CVD, MTCVD or similar techniques.

In another aspect of the invention, there is provided a method of manufacturing a sintered titanium-based carbonitride alloy. Hard constituent powders of TiC_xN_{1-x}, having x in the range 0.45-0.55 and an FSSS grain size of 1 to 2 µm, TaC, NbC and WC are mixed with powder of Co to a composition within the limits given above and pressed into bodies of desired shape. Sintering is performed in a N_2-Ar atmosphere, having a total pressure of 10-40 mbar and a partial pressure of N_2 of 0.5 to 4 mbar, at a temperature in the range 1370-1500°C for 0.5-1 h. It is within the purview of the skilled artisan to determine by experiments the conditions necessary to obtain the desired microstructure according to this specification.

Example 1

Three powder mixtures of nominal composition (wt%) Ti 46.4, Ta 8.2, Nb 4.2, W 17.1, Co 9.0, N 6.1 and a N/C ratio of 0.69(Alloy A, invention), 0.74 (Alloy B, reference) and 0.64 (Alloy C, reference) were prepared by wet milling of

$TiC_{0.50}N_{0.50}$ with a grain size FSSS of 1.25 µm
TaC, grain size 2.1 µm
NbC, grain size 2.0 µm
WC grain size 2.5 µm
Co grain size 0.80 µm
Pressing aid, PEG.

The powders were spray dried and pressed into SNUN120408 inserts. The inserts were dewaxed in H_2 and subsequently sintered in a N_2-Ar atmosphere, total pressure of 10 mbar and a partial pressure of N_2 of 1 mbar, for 1.0 h at 1480°C which was followed by grinding and conventional edge treatment. Polished cross sections of inserts were prepared by standard metallographic techniques and characterized using scanning electron microscopy. Fig. 1 and Fig. 2 show a scanning electron micrographs of such a cross section, taken in back scattering mode. The porosity was determined according to ISO 4505 standard. Magnetic properties were determined by standard methods.

	Relative magnetic saturation	Coercivity kA/m	Micro-porosity	Macro-porosity **
Alloy A	0.70	17.5	A02-B00-C00	0
Alloy B	0.43	15.0	A06-B02-C00	0
Alloy C	0.95	19.0	A02-B02-C00	4

** number of pores >25 µm per cm^2

The porosity levels of Alloy B and Alloy C, which are outside the preferred relative magnetic saturation range, are detrimental for the toughness.

Example 2

Six powder mixtures were prepared by wet milling of raw materials according to Example 1. For Alloy H and Alloy I a coarser $TiC_{0.50}N_{0.50}$ with a grain size of 3.5 µm was utilized. The nominal composition (wt%) is shown in the following table

	Co	Ti	Ta	Nb	W	N	C
Alloy D	13.5	43.4	7.7	4.0	rest	5.8	8.0
Alloy E	13.5	43.6	7.7	4.0	rest	5.8	8.6
Alloy F	18.0	40.8	7.2	3.7	rest	5.4	8.0
Alloy G	18.0	41.0	7.2	3.7	rest	5.4	8.5
Alloy H	20.0	39.0	7.0	3.6	rest	5.2	7.3
Alloy I	20.0	39.5	7.0	3.6	rest	5.2	7.8

Sintered inserts were prepared and analyzed according to Example 1. The results are found below:

	Relative magnetic saturation	Coercivity kA/m	Micro-porosity	Macro-porosity **	HV10
Alloy D	0.45	16.0	A02-B06-C00	6	1640
Alloy E	0.75	16.1	A00-B02-C00	0	1640
Alloy F	0.76	14.7	A00-B00-C00	2	1530
Alloy G	0.94	14.7	A06-B04-C00	2	1510
Alloy H	0.52	12.7	A00-B04-C00	10	1470
Alloy I	0.69	13.2	A01-B01-C00*	0	1470

* A01 indicates porosity level in between A00 and A02

* B01 indicates porosity level in between B00 and B02

** number of pores >25 µm per cm^2

The porosity levels of alloys outside the preferred relative magnetic saturation range are higher and, thus, detrimental for the toughness.

Example 3

Inserts of type DCMT 11T304 of alloys D and E according to example 2 were prepared. The magnetic properties of alloy E is within the present invention. However, the saturation magnetization of alloy D is outside. The inserts were used for turning of steel SS1672 at vc=200 m/min, f=0.10 mm and ap=0.25 mm. The surface roughness of the work piece, Ra, was monitored as a function of cutting time. At shorter times, <5 min the Ra value was similar for the two alloys, 1.2 µm. After 1 h of turning the Ra value for alloy D was 3.3 µm and for alloy E 1.8 µm. The considerably better surface finish of the work piece for alloy E is due to a better resistance to wear.

Example 4

Cutting tests utilizing inserts of type DCMT 11T304 of alloys G (outside invention) and F (according to invention) in a high toughness demanding work piece were done with following cutting data:

Work piece material: DIN42Cr41
Cutting speed=220 m/min,
Feed=0.2 mm/r,
Depth of cut=0.4 mm and
with coolant.
Result: Life time in number of passes, average of six edges.
Alloy G: 18
Alloy F: 28

Example 5

Plastic deformation resistance for the two alloys D (outside invention) and E (according to invention) was investigated in a turning test.

Work piece material: SS2541
depth of cut=1 mm, feed=0.3 mm/r, cutting time=2.0 min

The resistance to plastic deformation was determined as the maximum cutting speed at which no plastic deformation of the edge was detected.

Result: maximum cutting speed, average of two edges.
Alloy D: 240 m/min
Alloy E: 310 m/min

From the examples above it is clear that inserts produced according to the invention have both substantially improved toughness and deformation resistance.

Claims

1. A titanium based carbonitride alloy containing Ti, Nb, Ta, W, C, N and Co characterized in that the relative saturation magnetization is 0.60 to 0.90, preferably 0.65 to 0.80, and the magnetic coercivity Hc=(18.2-0.2*Co wt%) +/- E kA/m, where E is 2.0, preferably 1.5.

2. A titanium based carbonitride alloy according to claim 1 characterised in containing

- Co 7 to 21 wt%,
- W 14 to 20 wt%,
- Ta 5 to 11 wt%,
- Nb 2 to 7 wt%, and
- Ti 33 to 50 wt%.

3. A titanium based carbonitride alloy according to claim 2 characterised in containing

- W 16 to 18 wt%,
- Ta 6 to 9 wt%,
- Nb 3 to 5 wt%, and
- Ti 37 to 47 wt%.

4. A titanium based carbonitride alloy according to claims 2 or 3 characterised in containing

- Co 8 to 15 wt%.

5. A titanium based carbonitride alloy according to claims 2 or 3 characterised in containing

- Co 15 to 20 wt%.

6. A titanium based carbonitride alloy according to any of claims 2 to 5 characterised in an overall N/C weight ratio of 0.6 to 0.75.

7. A titanium based carbonitride alloy according to any of claims 2 to 6 characterised in a Ta/Nb weight ratio of 1.8 to 2.1.

8. A titanium based carbonitride alloy according to any of the preceding claims characterised in being coated with a thin wear resistant coating using PVD, CVD, MTCVD or similar techniques.

9. Method of manufacturing a sintered titanium-based carbonitride alloy containing Ti, Nb, Ta, W, C, N and Co by mixing hard constituent powders of TiC_xN_{1-x} having x in the range 0.45-0.55 and an FSSS grain size of 1 to 2 µm, TaC, NbC and WC with powder of Co to a composition and pressing into bodies of desired shape,

sintering in a N_2-Ar atmosphere, characterised said atmosphere having a total pressure of 10-40 mbar and a partial pressure of N_2 of 0.5 to 4 mbar, at a temperature of 1370-1500°C for 0.5-1 h.

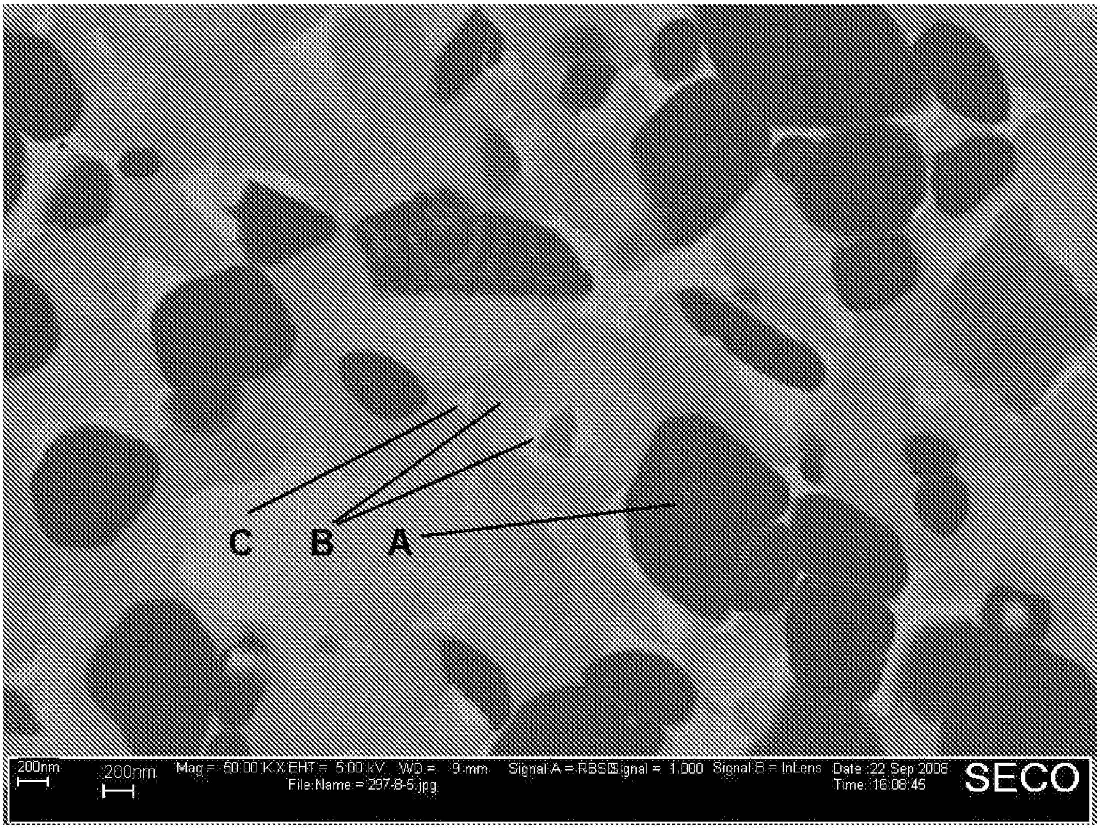

Figure 1.

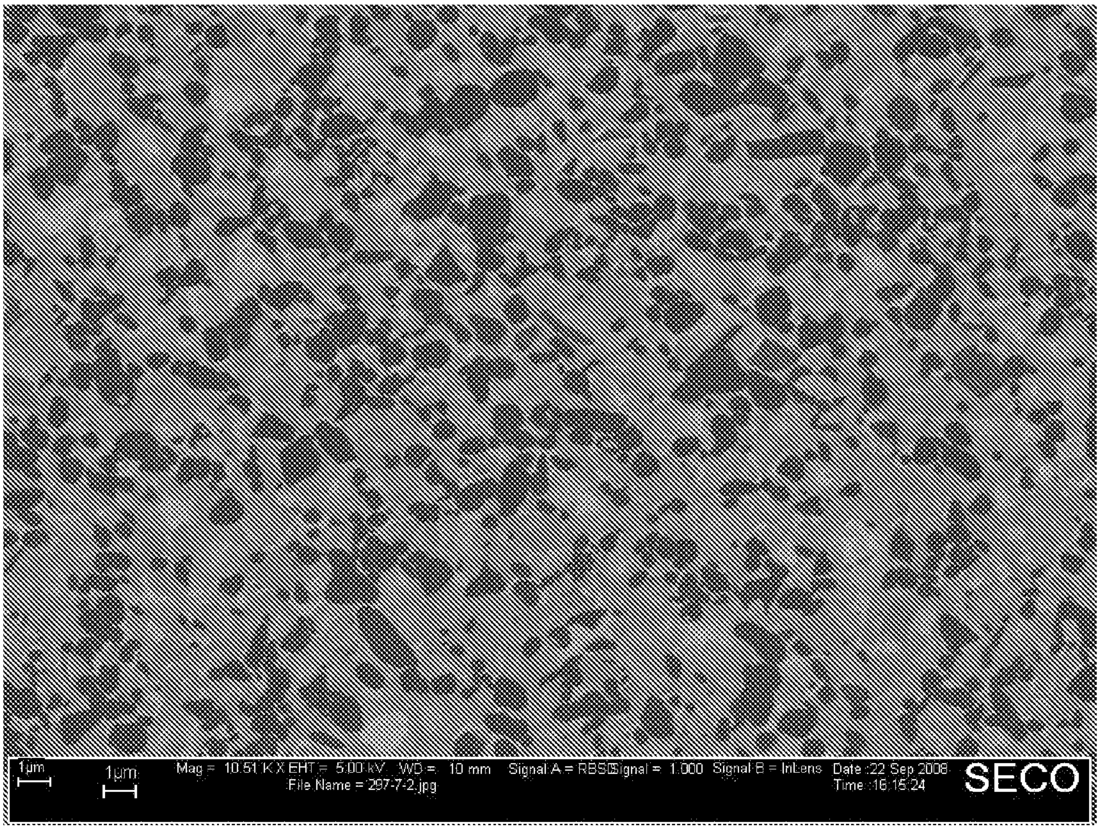

Figure 2.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/051448

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B22F, C04B, C22C, C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6344170 B1 (ROLANDER U. ET AL), 5 February 2002 (05.02.2002), abstract --	1-9
A	US 6325838 B1 (WEINL G. ET AL), 4 December 2001 (04.12.2001), abstract --	1-9
A	US 6340445 B1 (PIIRHONEN A. ET AL), 22 January 2002 (22.01.2002), abstract -- --------	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 14 April 2010	Date of mailing of the international search report 16-04-2010
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anna-Maj Magnusson/ELY Telephone No. +46 8 782 25 00

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C22C 29/04 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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