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(54) **INSERT FOR MILLING OF CAST IRON**

EINSATZ ZUM FRÄSEN EINES GUSSSTÜCKES

PLAQUETTE POUR LE FRAISAGE DE LA FONTE

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(73) Proprietor: **Seco Tools AB**
737 82 Fagersta (SE)

(72) Inventors:
- **LARSSON, Andreas**
  S-737 33 Fagersta (SE)
- **LARSSON, Tommy**
  S-737 90 Ängelsberg (SE)
- **ANDERSSON, Jon**
  S-723 51 Västerås (SE)

(74) Representative: **Hägglöf, Henrik**
Sandvik Intellectual Property AB
811 81 Sandviken (SE)

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Description

[0001] The present invention relates to a coated cemented carbide milling insert for wet or dry machining of cast iron such as nodular cast irons. Such inserts are described in EP-A-1 798 310 and EP-A-1 867 741.

[0002] During milling of various materials with coated cemented carbide cutting tools, the cutting edges are regarded as being worn according to different wear mechanisms. Wear types such as chemical wear, abrasive wear and adhesive wear, are rarely encountered in a pure state, and complex wear patterns are often the result. The domination of any of the wear mechanisms is determined by the application, and is dependent on properties of the machined material, applied cutting parameters and the properties of the tool material. The machinability of cast irons can vary considerably between the various groups but also within a certain group. Small variation in the chemical composition or the micro-structure, related to the casting technique, can have significant influence on the tool life.

[0003] In general, the different cast irons are very demanding when it comes to wear resistance and therefore CVD-coated inserts have been commonly used. However, in some applications these inserts do not have the combination of edge toughness and wear resistance needed.

[0004] EP 1205569 discloses a coated milling insert particularly useful for milling of grey cast iron with or without cast skin under wet conditions at low and moderate cutting speeds and milling of nodular cast iron and compacted graphite iron with or without cast skin under wet conditions at moderate cutting speeds. The insert is characterised by a WC-Co cemented carbide with a low content of cubic carbides and a highly W-alloyed binder phase and a coating including an inner layer of TiC_xN_y with columnar grains followed by a layer of $K-Al_2O_3$ and a top layer of TiN.

[0005] EP 1655391 discloses coated milling inserts particularly useful for milling of grey cast iron with or without cast skin under dry conditions at preferably rather high cutting speeds and milling of nodular cast iron and compacted graphite iron with or without cast skin under dry conditions at rather high cutting speeds. The inserts are characterised by a WC-Co cemented carbide with a low content of cubic carbides and a highly W-alloyed binder phase and a coating including an inner layer of TiC_xN_y with columnar grains followed by a wet blasted layer of $\alpha-Al_2O_3$.

[0006] It is an object of the present invention to provide a coated cutting tool with enhanced performance for wet or dry milling of cast irons.

[0007] The cutting tool insert according to the present invention includes a cemented carbide substrate with a relatively low amount of cubic carbides, with a relatively low binder phase content, that is medium to highly alloyed with W and a fine to medium WC grain size. This substrate is provided with a wear resistant coating comprising a $(Ti_xAl_{1-x})N$ layer.

[0008] Fig 1 shows in 40000x a scanning electron microscopy image of a fracture cross section of a cemented carbide insert according to the present invention in which

1. Cemented carbide body and
2. $(Ti_xAl_{1-x})N$ layer.

[0009] According to the present invention a coated cutting tool insert is provided consisting of a cemented carbide body and a coating. The cemented carbide body has a composition of 5-7, preferably 5.5-6.5, most preferably 5.8-6.2 wt% Co, 0.05-2.0 wt%, preferably 0.08-1.5 wt%, most preferably 0.1-1.2 wt% total amount of the metals Ti, Nb and Ta and balance WC.

[0010] In a preferred embodiment, the content of Ti and Nb is on a level corresponding to a technical impurity.

[0011] The coercivity (Hc)of the cemented carbide is 14-19 kA/m, preferably 14.8-18.3 kA/m.

[0012] The cobalt binder phase is medium to highly alloyed with tungsten. The content of W in the binder phase may be expressed as the S-value=σ/16.1, where o is the measured magnetic moment of the binder phase in μTm^3kg^{-1}. The S-value depends on the content of tungsten in the binder phase and increases with a decreasing tungsten content. Thus, for pure cobalt, or a binder in a cemented carbide that is saturated with carbon, S=1, and for a binder phase that contains W in an amount that corresponds to the borderline to formation of n-phase, S=0.78.

[0013] The cemented carbide body has an S-value of 0.81-0.96, preferably 0.84-0.95, most preferably 0.85-0.95.

[0014] The coating comprises a layer of $(Ti_xAl_{1-x})N$, where x is between 0.25 and 0.50, preferably between 0.30 and 0.40, most preferably between 0.33 and 0.35. The crystal structure of the (Ti,Al)N-layer is of NaCl type. The total thickness of the layer is between 1.0 and 5.0 μm, preferably between 1.5 and 4.0 μm. The thickness is measured on the middle of the flank face.

[0015] In a preferred embodiment, the layer is strongly textured in the (200)-direction, with a texture coefficient TC(200) larger than 1.3, preferably between 1.5 and 2.5.

[0016] The texture coefficient (TC) is defined as follows:

$$TC(hkl) = \frac{I(hkl)}{I_0(hkl)}\left[\frac{1}{n}\sum_{n=1}^{n}\frac{I(hkl)}{I_0(hkl)}\right]^{-1}$$

where
I(hkl) = intensity of the (hkl) reflection
I_O(hkl) = standard intensity according to JCPDS card no 38-1420
n = number of reflections used in the calculation
(hkl) reflections used are: (111), (200), (220).

[0017] The layer has a compressive residual stress with a strain of $2.5*10^{-3}$-$5.0*10^{-3}$, preferably $3.0*10^{-3}$-$4.0*10^{-3}$.

[0018] In an alternative embodiment, a layer of TiN between 0.1 and 0.5 μm thick is deposited on the final $(Ti_xAl_{1-x})N$ layer.

[0019] The present invention also relates to a method of making a cutting insert by powder metallurgical technique, wet milling of powders forming hard constituents and binder phase, compacting the milled mixture to bodies of desired shape and size and sintering, comprising a cemented carbide substrate and a coating. According to the method a substrate is provided consisting of 5-7, preferably 5.5-6.5, most preferably 5.8-6.2 wt% Co, 0.05-2.0 wt%, preferably 0.08-1.5 wt%, most preferably 0.1-1.2 wt% total amount of the metals Ti, Nb and Ta and balance WC.

[0020] In a preferred embodiment, the content of Ti and Nb is on a level corresponding to a technical impurity.

[0021] The manufacturing conditions are chosen to obtain an as-sintered structure with a coercivity, Hc, within 14-19 kA/m, preferably 14.8-18.3 kA/m and with a S-value within 0.81-0.96, preferably 0.84-0.95, most preferably 0.85-0.95.

[0022] Onto this substrate is deposited a coating comprising a $(TLAl_{1-x})N$ layer, where x is between 0.25 and 0.50, preferably between 0.30 and 0.40, most preferably between 0.33 and 0.35. The crystal structure of the (Ti,Al)N-layer is of NaCl type. The total thickness of the layer is between 1.0 and 5.0 μm, preferably between 1.5 and 4.0 μm. The thickness is measured on the middle of the flank face.

[0023] In a preferred embodiment, the method used to grow the layer is based on arc evaporation of an alloyed, or composite cathode, under the following conditions: The Ti+Al cathode composition is 25 to 50 at.% Ti, preferably 30 to 40 at.% Ti, most preferably 33 to 35 at.% Ti.

[0024] Before coating, the surface is cleaned preferably by applying a soft ion etching. The ion etching is performed in an Ar atmosphere or in a mixture of Ar and H_2.

[0025] The evaporation current is between 50 A and 200 A depending on cathode size and cathode material. When using cathodes of 63 mm in diameter the evaporation current is preferably between 60 A and 100 A. The substrate bias is between -20 V and -35 V. The deposition temperature is between 400°C and 700°C, preferably between 500°C and 600°C.

[0026] The (Ti,Al)N-layer is grown in an Ar+N_2 atmosphere consisting of 0-50 vol.% Ar, preferably 0-20 vol.%, at a total pressure of 1.0 Pa to 7.0 Pa, preferably 3.0 Pa to 5.5 Pa.

[0027] On top of the (Ti,Al)N-layer a TiN-layer of between 0.1 and 0.5 μm thickness may be deposited using Arc evaporation as known.

[0028] In a further preferred embodiment, the cutting tool insert as described above is treated after coating with a wet blasting or brushing operation, such that the surface quality of the coated tool is improved.

[0029] The present invention also relates to the use of a cutting tool insert according to above in milling of nodular cast iron, in both wet and dry conditions with a cutting speed of 75-300 m/min and feed per tooth of 0.05-0.4 mm.

<u>Example 1</u> (not according to the invention)

[0030] Grade A: A cemented carbide substrate with the composition 6 wt% Co, 0.2 Ta and balance WC, a binder phase alloyed with W corresponding to an S-value of 0.92 was produced by conventional milling of powders, pressing of green compacts and subsequent sintering at 1430°C. The Hc value for the cemented carbide was 16.5 kA/m, corresponding to a mean intercept length of about 0.65 μm. The substrate was coated in accordance with the invention with a (Ti,Al)N-layer, deposited by using cathodic arc evaporation. The layer was deposited using a Ti+Al cathode composition of 33 at.% Ti and the (Ti,Al)N layer was grown in an Ar+N_2 atmosphere. The thickness of the coating was 2.8 μm, when measured on the middle of the flank face. X-ray diffraction showed that the (Ti,Al)N layer had a TC(20C) of 1.8. Fig 1 shows in 40000x a scanning electron microscopy image of a fracture cross section of the coated cemented carbide.

[0031] Grade B: A substrate with composition 6 wt% Co, 0.2 Ta and balance WC, a binder phase alloyed with W corresponding to an S-value of 0.92, and a Hc value of 16.4 kA/m was coated with a 0.3 μm thick layer of TiN layer, a 4.2 μm thick layer of columnar MTCVD TiC_xN_y, and a 3.5 μm thick layer of α-Al_2O_3 deposited at about 1000°C.

[0032] Inserts of grade A and B were tested in a square shoulder milling operation in a nodular cast iron.

Operation	Square shoulder milling
Cutter diameter	45 mm
Work piece	Bridge
Material	GGG 60
Insert type	XOMX180608TR-MD15
Cutting speed	181 m/min
Feed	0.25 mm/tooth
Depth of cut	14 mm
Width of cut	12 mm
Coolant	No
Results	Tool life (pieces)
Grade A	1000
Grade B	700

[0033] The tool life of Grade A was limited by flank wear. The tool life of Grade B was limited by the combination of flank wear, chipping and thermal cracking.

Example 2

[0034] Grade C: A substrate with composition 7.6 wt% Co, 0.9 Ta, 0.3 Nb and balance WC, a binder phase alloyed with W corresponding to an S-value of 0.90, and a Hc value of 14 kA/m was coated with a 0.1 μm thick layer of TiN, a 2.8 μm thick layer of columnar MTCVD TiC_xN_y, a 2.1 μm thick layer of α-Al_2O_3 and a 0.5 μm thick layer of TiN, deposited at about 1000°C.

[0035] Grade D: A substrate with composition 8.1 wt% Co, 1.1 Ta, 0.3 Nb and balance WC, a binder phase alloyed with W corresponding to an S-value of 0.89, and a Hc value of 15 kA/m was combined with a coating according to Grade A.

[0036] Inserts of Grade A, B, C, and D were tested in a shoulder milling operation in a compacted graphite iron material.

Operation	Rough shoulder milling
Cutter diameter	63 mm
Component	Pump housing
Material	CGI
Insert type	XOMX180608TR-M14
Cutting speed	190 m/min
Feed	0.22 mm/tooth
Depth of cut	9.5 mm
Width of cut	51 mm
Coolant	No
Results	Tool life (pieces)
Grade A	116
Grade B	70
Grade C	24
Grade D	65

[0037] The tool life of Grades A and D was limited by flank wear. The tool life of Grades B and C was limited by the combination of flank wear, chipping and thermal cracking.

Example 3

[0038] Inserts of Grade A and B were tested in a face milling operation performed with a disc mill in nodular cast iron.

Operation	Face milling
Cutter diameter	180 mm
Material	FGS 400.12
Insert type	335.18-1005T
Cutting speed	100 m/min
Feed	0.10 mm/tooth
Depth of cut	2 mm
Width of cut	22 mm
Coolant	Yes
Results	Tool life (pieces)
Grade A	5480
Grade B	4500

[0039] The tool life of Grade A was limited by flank wear. The tool life of Grade B was limited by the combination of flank wear and delamination of the coating.

Claims

1. Cutting insert comprising a cemented carbide substrate and a coating particularly useful for milling of cast iron, where

- the substrate comprising 5-7, preferably 5.5-6.5, wt% Co, 0.05-2.0 wt%, preferably 0.08-1.5 wt%, total amount of the metals Ti, Nb and Ta, and balance WC with a coercivity (Hc) of 14-19 kA/m, preferably 14.8-18.3 kA/m and an S-value of 0.81-0.96, preferably 0.84-0.95 and
- the coating comprising a homogeneous layer of $(Ti_xAl_{1-x})N$, where x is between 0.25 and 0.50, preferably between 0.30 and 0.40, with a crystal structure of NaCl type and a total thickness of between 1.0 and 5.0 μm, preferably between 1.5 and 4.0 μm as measured on the middle of the flank face,

c h a r a c t e r i s e d in that the layer has a residual strain of between $2.5*10^{-3}$ and $5.0*10^{-3}$.

2. Cutting insert according to claim 1, wherein the layer has a texture coefficient TC(200) of >1.3, the texture coefficient (TC) being defined as:

$$\mathrm{TC(hkl)} = \frac{I(hkl)}{I_0(hkl)}\left[\frac{1}{n}\sum_{n=1}^{n}\frac{I(hkl)}{I_0(hkl)}\right]^{-1}$$

where
I(hkl) = intensity of the (hkl) reflection
I_O(hkl) = standard intensity according to JCPDS card no 38-1420 n = number of reflections used in the calculation
(hkl) reflections used are: (111), (200), (220).

3. Cutting insert according to any of the preceding claims, wherein the layer has a residual strain of between $3.0*10^{-3}$ and $4.0*10^{-3}$.

4. Cutting insert according to any of the preceding claims, wherein the content of Ti and Nb is on a level corresponding to technical impurity.

5. Cutting insert according to any of the preceding claims, wherein the coating comprises an outermost layer of TiN, with a thickness between 0.1 and 0.5 μm.

6. Method of making a cutting insert comprising a cemented carbide substrate and a coating, comprising preparing a substrate using conventional powder metallurgical technique comprising 5-7, preferably 5.5-6.5, wt% Co, 0.05-2.0 wt%, preferably 0.08-1.5 wt%, total amount of the metals Ti, Nb and Ta and balance WC with a coercivity (Hc)of 14-19 kA/m, preferably 14.8-18.3 kA/m and an S-value of 0.81-0.96, preferably 0.84-0.95 and
depositing a coating comprising a homogeneous layer of $(Ti_xAl_{1-x})N$, where x is between 0.25 and 0.50, preferably between 0.30 and 0.40, with a crystal structure of NaCl type and a total thickness of between 1.0 and 5.0 μm, preferably between 1.5 and 4.0 μm as measured on the middle of the flank face using arc evaporation of an alloyed, or composite cathode, with a composition of 25 to 50 at.% Ti, preferably 30 to 40 at.% Ti at an evaporation current of between 50 A and 200 A depending on cathode size and cathode material a substrate bias of between -20 V and -35 V and a temperature of between 400°C and 700°C, preferably between 500 °C and 600 °C in an $Ar+N_2$ atmosphere consisting of 0-50 vol.% Ar, preferably 0-20 vol.%, at a total pressure of 1.0 Pa to 7.0 Pa, preferably 3.0 Pa to 5.5 Pa.

7. Method according to claim 6, wherein the content of Ti and Nb is on a level corresponding to technical impurity.

8. Method according to any of claims 6 or 7,further comprising depositing an outermost layer of TiN between 0.1 and 0.5 μm thick using arc evaporation as known.

9. Use of a cutting tool insert according to claims 1-5 in milling of nodular cast iron, in both wet and dry conditions with a cutting speed of 75-300 m/min and feed per tooth of 0.05-0.4 mm.

Patentansprüche

1. Schneideinsatz aufweisend ein Hartmetallsubstrat und eine Beschichtung, wobei der Schneideinsatz insbesondere zum Fräsen von Gusseisen geeignet ist, wobei

- das Substrat 5-7, vorzugsweise 5,5-6,5, Gew.-% Co, 0,05-2,0 Gew.-%, vorzugsweise 0,08-1,5 Gew.-%, der Gesamtmenge der Metalle Ti, Nb und Ta aufweist und im Übrigen WC mit einer Koerzivität (Hc) von 14-19 kA/m, vorzugsweise 14,8-18,3 kA/m und einem S-Wert von 0,81-0,96, vorzugsweise 0,84-0,95, und
- die Beschichtung eine homogene Schicht aus (Ti_xAl1-x)N aufweist, wobei x zwischen 0,25 und 0,50, vorzugsweise zwischen 0,30 und 0,40, liegt und mit einer Kristallstruktur des NaCl-Typs und einer in der Mitte der Freifläche gemessenen Gesamtdicke von zwischen 1,0 und 5,0 μm, vorzugsweise zwischen 1,5 und 4,0 μm,
dadurch gekennzeichnet, dass die Schicht eine Eigenspannung zwischen $2,5*10^{-3}$ und $5,0*10^{-3}$ hat.

2. Schneideinsatz nach Anspruch 1, wobei die Schicht einen Texturkoeffizienten TC(200) von >1,3 aufweist und der Texturkoeffizient (TC) definiert ist als:

$$TC(hkl) = \frac{I(hkl)}{I_0(hkl)}\left[\frac{1}{n}\sum_{n=1}^{n}\frac{I(hkl)}{I_0(hkl)}\right]^{-1}$$

wobei
I(hkl) = Intensität der (hkl)-Reflexion
I_0(hkl) = Standardintensität nach JCPDS-Karte Nr. 38-1420
n = Anzahl der in der Berechnung verwendeten Reflexionen, wobei die verwendeten (hkl)-Reflexionen sind: (111), (200), (220).

3. Schneideinsatz nach einem der vorangehenden Ansprüche, wobei die Schicht eine Eigenspannung zwischen $3,0*10^{-3}$ und $4,0*10^{-3}$ hat.

4. Schneideinsatz nach einem der vorangehenden Ansprüche, wobei der Anteil von Ti und Nb einem Grad technischer Verunreinigung entspricht.

5. Schneideinsatz nach einem der vorangehenden Ansprüche, wobei die Beschichtung eine äußere, zwischen 0,1 und 0,5 μm dicke Schicht aus TiN aufweist.

6. Verfahren zum Herstellen eines Schneideinsatzes aufweisend ein Hartmetallsubstrat und eine Beschichtung, wobei das Verfahren das Bereitstellen eines Substrates unter Verwendung herkömmlicher pulvermetallurgischer Verfahren umfasst und wobei das Substrat 5-7, vorzugsweise 5,5-6,5, Gew.-% Co, 0,05-2,0 Gew.-%, vorzugsweise 0,08-1,5 Gew.-%, der Gesamtmenge der Metalle Ti, Nb und Ta aufweist und im Übrigen WC mit einer Koerzivität (Hc) von 14-19 kA/m, vorzugsweise 14,8-18,3 kA/m und einem S-Wert von 0,81-0,96, vorzugsweise 0,84-0,95, und

Abscheiden einer Beschichtung, welche eine homogene Schicht aus $(Ti_xAl_{1-x})N$ aufweist, wobei x zwischen 0,25 und 0,50, vorzugsweise zwischen 0,30 und 0,40, ist und mit einer Kristallstruktur des NaCl-Typs und einer in der Mitte der Freifläche gemessenen Gesamtdicke von zwischen 1,0 und 5,0 μm unter Verwendung von Lichtbogenverdampfen einer Legierung oder mit einer Verbundkathode mit einer Zusammensetzung von 25 bis 50 at.-% Ti, vorzugsweise 30 bis 40 at.-% Ti, bei einem Verdampfungsstrom zwischen 50 A und 200 A in Abhängigkeit der Kathodengröße und des Kathodenmaterials, einer Substratvorspannung zwischen -20 V und -35 V und einer Temperatur zwischen 400 °C und 700 °C, vorzugsweise zwischen 500 °C und 600 °C, in einer $Ar+N_2$-Umgebung bestehend aus 0-50 Vol.-% Ar, vorzugsweise 0-20 Vol.-%, und bei einem Gesamtdruck von 1,0 Pa bis 7,0 Pa, vorzugsweise 3,0 Pa bis 5,5 Pa.

7. Verfahren nach Anspruch 6, wobei der Anteil von Ti und Nb einem Grad technischer Verunreinigung entspricht.

8. Verfahren nach einem der Ansprüche 6 oder 7, weiter aufweisend Abscheiden einer äußeren, zwischen 0,1 und 0,5 μm dicken Schicht aus TiN mittels bekannten Lichtbogenverdampfens.

9. Verwendung eines Schneidwerkzeugeinsatzes nach einem der Ansprüche 1 bis 5 beim Fräsen von nodularem Gusseisen bei Nass- und/oder Trockenbedingungen mit einer Schneidgeschwindigkeit von 75-300 m/min und einem Vorschub pro Zahn von 0,05-0,4 mm.

Revendications

1. Plaquette de coupe comprenant un substrat de carbure cémenté et un revêtement particulièrement utile pour le fraisage de la fonte, où

- le substrat comprend de 5 à 7, de préférence de 5,5 à 6,5 %, en poids de Co, de 0,05 à 2,0 % en poids, de préférence de 0,08 à 1,5 % en poids, de quantité totale des métaux Ti, Nb et Ta, et le reste de WC avec une coercivité (Hc) de 14 à 19 kA/m, de préférence de 14,8 à 18,3 kA/m et une valeur S de 0,81 à 0,96, de préférence de 0,84 à 0,95 et
- le revêtement comprend une couche homogène de $(Ti_xAl_{1-x})N$, où x se trouve entre 0,25 et 0,50, de préférence entre 0,30 et 0,40, avec une structure cristalline de type NaCl et une épaisseur totale entre 1,0 et 5,0 μm, de préférence entre 1,5 et 4,0 μm telle que mesurée au milieu de la face du flanc,

caractérisée en ce que la couche présente une contrainte résiduelle entre $2,5x10^{-3}$ et $5,0x10^{-3}$.

2. Plaquette de coupe selon la revendication 1 dans laquelle la couche présente un coefficient de texture TC(200) > 1,3, le coefficient de texture (TC) étant défini par :

$$TC(hkl) = \frac{I(hkl)}{I_0(hkl)}\left[\frac{1}{n}\sum_{n=1}^{n}\frac{I(hkl)}{I_0(hkl)}\right]^{-1}$$

où
I(hkl) intensité de la réflexion (hkl)
$I_0(hkl)$ intensité standard selon la carte JCPDS n°38-1420 n= nombre de réflexions utilisées dans le calcul
les réflexions (hkl) utilisées sont : (111), (200), (220).

3. Plaquette de coupe selon l'une quelconque des revendications précédentes, dans laquelle la couche présente une contrainte résiduelle entre $3,0x10^{-3}$ et $4,0x10^{-3}$.

4. Plaquette de coupe selon l'une quelconque des revendications précédentes, dans laquelle la teneur en Ti et en Nb est à un niveau correspondant à l'impureté technique.

5. Plaquette de coupe selon l'une quelconque des revendications précédentes, dans laquelle le revêtement comprend une couche la plus à l'extérieur de TiN, avec une épaisseur entre 0,1 et 0,5 μm.

6. Procédé de fabrication d'une plaquette de coupe comprenant un substrat de carbure cémenté et un revêtement, comprenant la préparation d'un substrat en utilisant une technique métallurgique des poudres classique comprenant de 5 à 7, de préférence de 5,5 à 6,5 %, en poids de Co, de 0,05 à 2,0 % en poids, de préférence de 0,08 à 1,5 % en poids, de quantité totale des métaux Ti, Nb et Ta, et le reste de WC avec une coercivité (Hc) de 14 à 19 kA/m, de préférence de 14,8 à 18,3 kA/m et une valeur S de 0,81 à 0,96, de préférence de 0,84 à 0,95 et
le dépôt d'un revêtement comprenant une couche homogène de $(Ti_xAl_{1-x})N$,
où x se trouve entre 0,25 et 0,50, de préférence entre

0,30 et 0,40, avec une structure cristalline de type NaCl et une épaisseur totale entre 1,0 et 5,0 μm, de préférence entre 1,5 et 4,0 μm telle que mesurée au milieu de la face du flanc en utilisant une évaporation à l'arc d'une cathode alliée ou composite, avec une composition de 25 à 50 % atomiques de Ti, de préférence de 30 à 40 % atomiques de Ti à un courant d'évaporation entre 50 A et 200 A en fonction des dimensions de la cathode et du matériau de la cathode, une polarisation de substrat entre -20 V et -35 V et une température entre 400° C et 700° C, de préférence entre 500° C et 600° C dans une atmosphère de Ar+N_2 constituée de 0 à 50 % en volume de Ar, de préférence de 0 à 20 % en volume, à une pression totale de 1,0 Pa à 7,0 Pa, de préférence de 3,0 Pa à 5,5 Pa.

7. Procédé selon la revendication 6, dans lequel la teneur en Ti et en Nb est à un niveau correspondant à l'impureté technique.

8. Procédé selon l'une quelconque des revendications 6 ou 7, comprenant en outre le dépôt d'une couche la plus à l'extérieur de TiN d'une épaisseur entre 0,1 et 0,5 μm en utilisant une évaporation à l'arc comme cela est connu.

9. Utilisation d'une plaquette d'outil de coupe selon les revendications 1 à 5 pour le fraisage de fonte nodulaire, à la fois dans des conditions humides et sèches avec une vitesse de coupe de 75 à 300 m/min et une avance par dent de 0,05 à 0,4 mm.

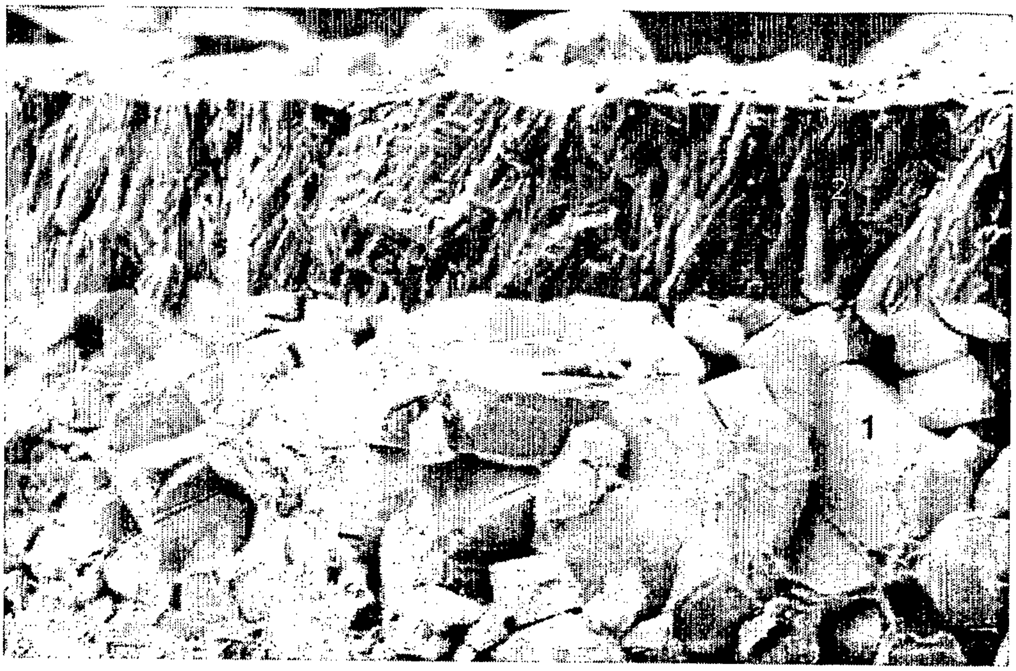

Fig 1

REFERENCES CITED IN THE DESCRIPTION

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