Claims

What is claimed is:

1 Tool comprising a body 1, preferably a cutting tool comprising a body of a hard alloy of cemented carbide, cermet, ceramics, cubic boron nitride based material or high speed steel, onto which is deposited a hard and wear resistant PVD coating characterized in that said coating comprises a nanolaminated structure 5 of alternating A and B layers A1, A2, A3,... An and B1, B2, B3,... Bm, respectively, where layer A is $(Al_xTi_{1-x-y}W_y)N$, with $0.50 \leq x \leq 0.65$ and $0 \leq y \leq 0.10$, where the coefficients given by x, 1-x-y and y correspond to the atomic concentration of aluminum, titanium and tungsten, respectively, considering only the elements aluminum, titanium and tungsten for the element quantification in said layer A, and where layer B is $(Ti_{1-z-u}Si_zW_u)N$, with $0.05 \leq z \leq 0.30$ and $0 \leq u \leq 0.10$, where the coefficients given by 1-z-u, z and u correspond to the atomic concentration of titanium, silicon and tungsten, respectively, considering only the elements titanium, silicon and tungsten for the element quantification in said layer B, with a thickness of the nanolaminated structure between 0.01 and 30 µm, preferably between 1 and 15 µm, an average individual thickness of the A and B layers is between 1 and 200 nm, respectively, preferably between 1 and 50 nm, more preferably between 1 and 30 nm, **characterized in that** said nanolaminated structure of alternating A and B layers exhibits a fine-grained structure.

2. Coated body according to claim 1 **characterized in that** the thickness of the A layers, referred to as dA1, dA2, dA3... dAn, is equal or smaller than the thickness of

the B layers, referred to as dB1, dB2, dB3... dBm, comprised in the nanolaminated structure of alternating A and B layers, preferably the thickness of the A layers is equal or smaller than ¾ of the thickness of the B layers: dA1 ≤ ¾ dB1, dA2 ≤ ¾ dB2, dA3 ≤ ¾ dB3, dAn ≤ ¾ dBm,

3. Coated body according to claim 2 **characterized in that** in at least a portion of the total thickness of the nanolaminated structure

- the thickness of the A layers and/or the thickness of the B layers remains constant, so that dA1 = dA2 = dA3... = dAn and/or dB1 = dB2 = dB3... = dBm,

and/or

- the thickness of A layers and/or the thickness of the B layers increases, so that dA1 ≥ dA2 ≥ dA3... ≥ dAn and/or dB1 ≥ dB2 ≥ dB3... ≥ dBm,

and/or

- the thickness of the A layers and/or the thickness of the B layers decreases, so that dA1 ≤ dA2 ≤ dA3... ≤ dAn and/or dB1 ≤ dB2 ≤ dB3... ≤ dBm

4. Coated body according to any one of the preceding claims **characterized in that**

- in said nano-layered coating system the sum of the thicknesses of a nano-layer of type A and a nano-layer of type B deposited alternately one on each other forming a nano-bilayer period is less than 300 nm, preferably less than 100 nm, more preferably between 5 and 50 nm, and
- said nano-layered coating system comprises at least a total of four individual nano-layers A and B deposited alternately one on each other forming a A1/B1/A2/B2/ or B1/A1/B2/A2 multilayer architecture, preferably at least a total

of ten individual nano-layers forming a A1/B1/A2/B2/A3/B3/A4/B4/A5/B5 or B1/A1/B2/A2/B3/A3/B4/A4/B5/A5 multilayer architecture.

5. Coated body according to any one of the preceding claims **characterized in that** said fine-grained nanolaminated structure features grains whose largest size is 1/3 of the overall thickness of the nanolaminated structure.

6. Coated body according to any one of the preceding claims **characterized in that** said fine-gained nanolaminated structure features grains whose average size is maximal 1000 nm, preferably between 10 and 800 nm, more preferably between 10 and 400 nm.

7. Coated body according to any one of the preceding claims **characterized in that** said nanolaminated structure is or comprises an equiaxed structure in which the grains have approximately the same dimensions in all directions.

8. Coated body according to any one of the preceding claims **characterized in that** said nanolaminated structure features an average residual stress, σ, between 2.5 and 5 GPa, preferably between 2.5 and 4 GPa.

9. Coated body according to any one of the preceding claims **characterized in that** said nanolaminated structure features a ratio of the peak width $PW_{I_10/90}$ is less than 7.5, preferably less than 7, where

- $PW_{I_10/90}$°=°$PW_{I_10\%}$ / $PW_{I_90\%}$,
- $PW_{I_10\%}$ and $PW_{I_90\%}$ are the meaning full width of the peak 200 at 10% and 90% of the maximum peak intensity, respectively, and

- the 200 peak is measured using X-ray diffraction with CuKα radiation at approximately 43° in the 2θ axis, and the diffraction line is corrected regarding contribution from $CuK\alpha_2$ radiation, diffraction statistics (smoothening) and background.

10. Coated body according to any one of the preceding claims **characterized in that** said coating comprises

- at least one interlayer 2 deposited between the substrate 1 and said nano-layered coating film 5, and/or
- at least one top-layer 3 deposited on the outermost nano-layer of the nano-layered coating film 5.

11. Coated body according to any one of the preceding claims **characterized in that** said body is a drilling or a milling tool.

12. Use of a coated body according to any one of the preceding claims for cutting operations, preferably for drilling or milling operations, more preferably for drilling of steel, stainless steel, or cast iron or milling of hardened or stainless steel.

13. Method for manufacturing a coated body according to any one of the preceding claims from 1 to 11 within which at least one arc vaporization source is used for the deposition of the nano-layered coating film on the substrate surface, **characterized in that**

the at least one arc evaporation source comprises a magnetic field arrangement provided on a target for generating magnetic fields on and above the target surface, wherein the magnetic field arrangement comprises marginal permanent magnets and

at least one ring coil placed behind the target, whose inner diameter defined by the windings is smaller than or equal to, and in any case not considerably larger than the diameter of the target, and the marginal permanent magnets can be displaced away from the target essentially perpendicularly to the surface of the target and the projection of the marginal permanent magnets onto the target surface is further away from the middle of the target surface by comparison to the projection of the ring coil onto the target surface, the inner or internal, centric permanent magnet is positioned back away rear in relation to the target and the outer or outside permanent magnet is positioned at a distance of several millimeters in relation to the target, preferably between 6 and 10 mm, more preferably ca. 8 mm.

14. Method according to claim 13 **characterized in that** a negative coil current is applied, the applied coil current is preferably between -0.1 and -1 A.

15. Method for manufacturing a coated body according to any one of the preceding claims from 1 to 11 within which at least one arc vaporization source is used for the deposition of the nano-layered coating film on the substrate surface, **characterized in that**

the at least one arc evaporation source comprises a target used as a cathode, an anode arranged in the direct neighborhood of the cathode, and magnetic means which allow to lead the streamlines of the magnetic field to the anode.

16. Method according to claim 15 **characterized in that** a positive coil current is applied, the applied coil current is preferably between 0.5 and 2 A.

17. Method according to any one of the preceding claims from 11 to 15 **characterized in that** as source material for the deposition of the nanolaminated structure

- at least one composite target made by means of powder-metallurgical techniques, comprising aluminum and titanium and/or tungsten are used for the deposition of the nano-layer of type A, and/or
- at least one composite target made by means of melt-metallurgical techniques, comprising titanium and silicon and/or tungsten are used for the deposition of the nano-layer of type B.

What is claimed is:

1 Coated body (1) comprising a body having a surface to be coated onto which a hard and wear resistant PVD coating is deposited, said coating comprising a nanolaminated structure (5) of alternating A- and B-nanolayers, wherein the A-nanolayers have element composition $(Al_xTi_{1-x-y}W_y)N$, with $0.50 \leq x \leq 0.65$ and $0 \leq y \leq 0.10$, where the coefficients given by x, 1-x-y and y correspond to the atomic concentration of aluminum, titanium and tungsten, respectively, considering only the elements aluminum, titanium and tungsten for the element quantification in said A-nanolayers, and the B-nanolayers have composition $(Ti_{1-z-u}Si_zW_u)N$, with $0.05 \leq z \leq 0.30$ and $0 \leq u \leq 0.10$, where the coefficients given by 1-z-u, z and u correspond to the atomic concentration of titanium, silicon and tungsten, respectively, considering only the elements titanium, silicon and tungsten for the element quantification in said B-nanolayers, with an average individual thickness of the A- and B-nanolayers between 1 and 200 nm, respectively, **characterized in that** said nanolaminated structure (5) of alternating A- and B- nanolayers exhibits a fine-grained structure, said fine-grained structure being characterized by exhibiting in SEM micrographs of fractured cross sections of the coating a microstructure free of columns and by comprising grains whose largest size is 1/3 of the overall thickness of the nanolaminated structure.

2. Coated body according to claim 1 **characterized in that** said nanolaminated structure is or comprises an equiaxed structure in which the grains have approximately the same dimensions in all directions.

3. Coated body according to any one of the preceding claims **characterized in that**

- said nanolaminated structure exhibits an average residual stress, σ, between 2.5 and 5 GPa, preferably between 2.5 and 4 GPa

and/or

- said nanolaminated structure exhibits a ratio of the peak width $PW_{I_10/90}$ which is less than 7.5 by considering that $PW_{I_10/90}$°=°$PW_{I_10\%}$ / $PW_{I_90\%}$, $PW_{I_10\%}$ and $PW_{I_90\%}$ are the meaning full width of the peak 200 at 10% and 90% of the maximum peak intensity, respectively, and the 200 peak is measured using X-ray diffraction with CuKα radiation at approximately 43° in the 2θ axis, and the diffraction line is corrected regarding contribution from CuKα_2 radiation, diffraction statistics (smoothening) and background.

4. Coated body according to any one of the preceding claims **characterized in that** the coated body is a coated tool for cutting operations.

5. Coated cutting tool according to claim 4 characterized in that the body is made of or comprises a hard alloy of cemented carbide, or cermet, or ceramics, or a cubic boron nitride based material or high speed steel and can be used for drilling of steel or stainless steel or cast iron, or for milling of hardened steel or stainless steel.

6. Method for manufacturing a coated body having at least a surface coated with a coating comprising a nanolaminated structure (5) of alternating A nano-layers consisting of at least 90 at.-% AlTiN and B nano-layers consisting of at least 90 at.-% TiSiN, wherein at least two arc vaporization sources are used for the deposition of the nanolaminated structure (5) on the substrate surface to be coated, **characterized in that**

- each one of the at least two arc evaporation sources comprises a magnetic field arrangement provided on a target for generating magnetic fields on and above the target surface, wherein the magnetic field arrangement comprises marginal permanent magnets, a centric permanent magnet and at least one ring coil placed behind the target, whose inner diameter defined by the windings is smaller than or equal to, and in any case not considerably larger than the diameter of the target, and during the deposition of the nanolaminated structure the marginal permanent magnets are positioned away from the target, at a distance of several millimeters in relation to the target, in such a manner that the projection of the marginal permanent magnets onto the target surface is further away from the middle of the target surface by comparison to the projection of the ring coil onto the target surface, and the centric permanent magnet is positioned back away rear in relation to the target, and

- the target of one of the at least two arc evaporator sources comprises AlTi and the target of the another arc evaporator source comprises TiSi, and

- the distance between the permanent magnets and the target in each one of the at least two evaporation sources, are adjusted in such a manner that the nanolaminated film is deposited having a fine-grained microstructure which exhibits in SEM micrographs of fractured cross sections of the coating a microstructure free of columns.

7. Method according to claim 6 **characterized in that** the distance between the permanent magnets and the target is between 6 and 10 mm, preferably about 8 mm.

8. Method according to any of the claims 6 or 7 **characterized in that** a negative coil current is applied.

9. Method according to claim 8 **characterized in that** the applied coil current is between -0.1 and -1 A.

10. Method for manufacturing a coated body having at least a surface coated with a coating comprising a nanolaminated structure (5) of alternating A nano-layers consisting of at least 90 at.-% AlTiN and B nano-layers consisting of at least 90 at.-% TiSiN, wherein at least two arc vaporization source are used for the deposition of the nanolaminated structure (5) on the substrate surface to be coated, **characterized in that**

- each one of the at least two arc evaporation sources comprises a target used as a cathode, an anode arranged in the direct neighborhood of the cathode, and magnetic means for producing a magnetic field, whose streamlines are led to the anode, wherein the arc evaporators are operated by setting coil currents and arc currents, and

- the coil current in each one of the at least two evaporation sources, are adjusted in such a manner that the nanolaminated film is deposited having a fine-grained

microstructure which can be observed in SEM micrographs of fractured cross sections of the coating.

11. Method according to claim 10 **characterized in that** a positive coil current is applied.

12. Method according to claim 11 **characterized in that** the applied coil current is between 0.5 and 2 A.

13. Method according to any one of the preceding claims from 6 to 12 **characterized in that**

- one of the at least two arc evaporation sources comprises a composite target comprising as main components in atomic percentage aluminum and titanium, and at least this target is used as material source for the deposition of the A nano-layers, and

- one of the at least two arc evaporation sources comprises a composite target comprising as main components in atomic percentage titanium and silicon, and at least this target is used as material source for the deposition of the B nano-layers.

14. Method according to any of the claims 6 to 13 **characterized in that** the nanolaminated structure (5) is deposited in a coating chamber which at least during

the deposition of the nanolaminated structure (5) has a reactive atmosphere comprising as main component nitrogen.

15. Method according to claim 14 **characterized in that** at least during a part of the deposition of the nanolaminated structure

- the nitrogen partial pressure is between 4 and 7 Pa, and/or

- a negative DC bias voltage is applied to the body to be coated and has a value of between -20 and -60, and/or

- the body surface to be coated is maintained at a temperature not lower than 450 °C and not higher than 700 °C.