

Furthermore, document JP2009012139 discloses a cutting tool whose surface is coated with a hard AlCrBN coating layer that possess a layer thickness of 0.8 – 5 μm . It is mentioned that the described AlCrBN coating layer provides high hardness, excellent lubricity and wear resistance in high speed cutting of materials with high weldability. The disclosed AlCrBN coating consists of a first film deposited on the substrate surface having a composition of $(\text{Al}_x\text{Cr}_{1-x}\text{B}_y)\text{N}_z$ with $0.5 \leq X \leq 0.7$, $0.001 \leq Y \leq 0.1$, $0.9 \leq Z \leq 1.25$, $X+Y < 0.75$ and a second film deposited on the first film having a composition of $(\text{Al}_a\text{Cr}_{1-a}\text{B}_b)\text{N}_c$ with $0.4 \leq a \leq 0.7$, $1 \leq b \leq 2.5$, $0.25 \leq c \leq 0.68$. The overall coating has an average composition of $\text{Al}_\alpha\text{Cr}_{1-\alpha}\text{B}_\beta\text{N}_\gamma$ where $0.5 \leq \alpha \leq 0.7$, $0.003 \leq \beta \leq 0.12$, $0.8 \leq \gamma \leq 1.25$.

Objective of the invention

The inventors observed that effectively single layer coatings of Al-Cr-B-N exhibit improved hardness and tribological behaviour in comparison to the well-established Al-Cr-N coatings. However there is still a need for further improvement. Al-Cr-B-N coatings exhibit in spite of their interesting properties also a very high residual stress. It worsens the cutting performance of the tools coated with these promising coating films. That is especially disadvantageous in applications requiring high coating thicknesses where particularly low residual stresses in the coatings are required in order to avoid coating delamination.

It is an objective of the present invention to provide coatings which exhibit a low residual stress, an enhanced hardness and improved wear coefficients as compared to Al-Cr-N and Al-Cr-B-N monolayer coatings.

Summary

In one aspect, there is provided a multilayer coating system deposited on at least a portion of a solid body surface and containing in a multilayer architecture Al-Cr-B-N individual layers deposited by means of a physical vapour deposition method characterized in that in at least a portion of the overall thickness of the multilayer coating system at least two Al-Cr-B-N individual layers are combined with at least two Ti- Al-N individual layers, wherein the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other, and wherein the thickness of the Al-Cr-B-N individual layers is greater than the thickness of the Ti-Al-N individual layers, and thereby residual stress of the multilayer coating system is considerably lower in comparison to residual stress of a corresponding analogical Al-Cr-B-N monolayer coating system.

In another aspect, there is provided a solid body at least partially coated with a multilayer coating system as defined herein.

Description of the invention

In order to attain reduced residual stresses in Al-Cr-B-N coatings different multilayer structures were synthesized by means of physical vapour deposition processes, preferably using reactive cathodic arc ion plating deposition methods.

The inventors surprisingly observed that the multilayer coating structures that particularly combine alternately Al-Cr-B-N and Ti-Al-N individual layers, especially when the thickness of the Al-Cr-B-N individual layers is thicker than the thickness of

Claims

1. Multilayer coating system deposited on at least a portion of a solid body surface and containing in the multilayer architecture Al-Cr-B-N individual layers deposited by means of a physical vapour deposition method **characterized in that** in at least a portion of the overall thickness of the multilayer coating system the Al-Cr-B-N individual layers are combined with Ti-Al-N individual layers, wherein the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other, and wherein the thickness of the Al-Cr-B-N individual layers is thicker than the thickness of the Ti-Al-N individual layers, and thereby the residual stress of the multilayer coating system is considerably lower in comparison to the residual stress of the corresponding analogical Al-Cr-B-N monolayer coating system and preferably the hardness of the multilayer coating system is larger or equal to the hardness of the corresponding analogical Al-Cr-B-N monolayer coating.
2. Multilayer coating system according to claim 1 **characterized in that** the thickness ratio of the Al-Cr-B-N individual layers related to the Ti-Al-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is basically 2:1.
3. Multilayer coating system according to claim 1 or 2 **characterized in that** the layer composition of the Al-Cr-B-N layers contained in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is $\text{Al}_a\text{Cr}_b\text{B}_c\text{N}_d$ with $a+b+c = 1$, $a = 9/5 \cdot y$, $0.1 \leq z \leq 0.3$ where a , b and c are the atomic fractions determined after element analysis taking only the elements Al, Cr and B into account for the element balance.
4. Multilayer coating system according to claims 1-3 **characterized in that** the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other contains at least two Ti-Al-N and two Al-Cr-B-N individual layers, more preferably at least three Ti-Al-N and three Al-Cr-B-N individual layers.

5. Multilayer coating system according to claims 1-4 **characterized in that** the thickness of the Ti-Al-N and Al-Cr-B-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other remains constant.
6. Multilayer coating system according to claims 1-5 **characterized in that** the element composition of the Al-Cr-B-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other remains constant.
7. Multilayer coating system according to claims 1-6 **characterized in that** the Al-Cr-B-N and Ti-Al-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other are nano-layers whose corresponding individual thicknesses are each one ≤ 100 nm, preferably the bilayer period defined as the sum of the thicknesses corresponding to one Al-Cr-B-N and one Ti-Al-N individual nano-layer is ≤ 100 nm, preferably is the bilayer period between 75 and 15 nm.
8. Multilayer coating system according to claims 1-7 **characterized in that** an additional Ti-Al-N individual layer is deposited between the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other and the substrate surface and whose values of thickness and elements concentration are equal or different to the corresponding values of the Ti-Al-N individual layers contained in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other.
9. Multilayer coating system according to claims 1-8 **characterized in that** an additional Al-Cr-B-N individual layer is deposited between the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other and the coating surface and whose values of thickness and elements concentration are equal or different to the corresponding values of the Al-Cr-B-N individual layers contained in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other.

10. Multilayer coating system according to claims 8-9 **characterized in that** the additional Ti-Al-N individual layer is deposited directly on the substrate surface and/or the additional Al-Cr-B-N individual layer is deposited as outermost layer.
11. Multilayer coating system according to claims 1-9 **characterized in that** an additional adhesion layer not consisting of Ti-Al-N is deposited directly on the substrate surface to improve the coating adhesion to substrate and/or an additional outermost layer not consisting of Al-Cr-B-N is deposited on the coating surface as top layer, this layer can be for example a thin decorative layer or a running-in layer.
12. Multilayer coating system according to claims 1-11 **characterized in that** the overall coating thickness of the multilayer coating system is equal or thicker than 3 μm , preferably equal or thicker than 5 μm .
13. Multilayer coating system according to claims 1-12 **characterized in that** at least the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is synthesized by reactive cathodic arc evaporation. Due to the deposition using arc evaporation macro particle of metallic materials from target are present in the coating. These macro particle contribute to improve the overall coating endurance strength by adding elasticity and they don't worsen the mechanical, thermal, chemical and tribological properties of the Al-Cr-B-N/Ti-Al-N multilayer coatings.
14. Multilayer coating system according to claims 1-13 **characterized in that** at least the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other exhibit a face-centered cubic structure in the as-deposited state.
15. Multilayer coating system according to claims 1-10 or 12-14 **characterized in that** the outermost layer is an Al-Cr-B-N layer that exhibits the formation of B_xN_y .
16. Solid body at least partially coated with a multilayer coating system according to claims 1-15.

17. Solid body according to claim 16 **characterized in that** the solid body is a cutting tool or a forming tool or a stamping tool, or a component or a part of a vehicle, or a component or part to be used in the motor industry or aerospace industry, in the last case for example a turbine component.
18. Method for manufacturing a solid body according to claims 16-17.

CLAIMS

1. A multilayer coating system deposited on at least a portion of a solid body surface and containing in a multilayer architecture Al-Cr-B-N individual layers deposited by means of a physical vapour deposition method characterized in that in at least a portion of the overall thickness of the multilayer coating system at least two Al-Cr-B-N individual layers are combined with at least two Ti- Al-N individual layers, wherein the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other, and wherein the thickness of the Al-Cr-B-N individual layers is greater than the thickness of the Ti-Al-N individual layers, and thereby residual stress of the multilayer coating system is considerably lower in comparison to residual stress of a corresponding analogical Al-Cr-B-N monolayer coating system.
2. The multilayer coating system according to claim 1 characterized in that a thickness ratio of the Al-Cr-B-N individual layers related to the Ti-Al-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is 2.1.
3. The multilayer coating system according to claim 1 characterized in that the layer composition of the Al-Cr-B-N layers contained in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is $Al_aCr_bB_cN_d$ with $a+b+c = 1$, $a = 9/5 \cdot y$, $0.1 \leq z \leq 0.3$ where a, b and c are the atomic fractions determined after element analysis taking only the elements Al, Cr and B into account for the element balance, and where y and z are atomic fractions of Cr and B for at least one alloyed source material target containing aluminum, chromium and boron with the following element composition, $Al_xCr_yB_z$, where $x+y+z=1$, $x=1.8 \cdot y$ and $0.1 \leq z \leq 0.3$, with x, y, and z values are atomic fractions.
4. The multilayer coating system according to claim 1 characterized in that the thickness of the Ti-Al-N and Al-Cr-B-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other remains constant.

5. The multilayer coating system according to claim 1 characterized in that the element composition of the Al-Cr-B-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other remains constant.

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6. The multilayer coating system according to claim 1 characterized in that the Al-Cr-B-N and Ti-Al-N individual layers in the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other are nano-layers whose corresponding individual thicknesses are each ≤ 100 nm.

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7. The multilayer coating system according to claim 1 characterized in that an additional Ti-Al-N individual layer is deposited between the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other and a substrate surface; and said additional Ti-Al-N individual layer's values of thickness and elements concentration are equal or different to the corresponding values of the Ti-Al-N individual layers contained in the coating portion.

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8. The multilayer coating system according to claim 1 characterized in that an additional Al-Cr-B-N individual layer is deposited between the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other and the coating surface; and said additional Al-Cr-B-N individual layer's values of thickness and elements concentration are equal or different to the corresponding values of the Al-Cr-B-N individual layers contained in the coating portion.

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9. The multilayer coating system according to claims 7-8 characterized in that the additional Ti-Al-N individual layer is deposited directly on the substrate surface and/or the additional Al-Cr-B-N individual layer is deposited as outermost layer.

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10. The multilayer coating system according to claim 1 characterized in that an additional adhesion layer not consisting of Ti-Al-N is deposited directly on the substrate surface to improve the coating adhesion to substrate and/or an additional outermost layer not consisting of Al-Cr-B-N is deposited on the coating surface as top layer.

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11. The multilayer coating system according to claim 1 characterized in that the overall coating thickness of the multilayer coating system is equal or thicker than 3 μm .

12. The multilayer coating system according to claim 1 characterized in that at least the
10 coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other is synthesized by reactive cathodic arc evaporation, wherein due to the deposition using arc evaporation macro particles of metallic materials from target are present in the coating.

15 13. The multilayer coating system according to claim 1 characterized in that at least the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other exhibit a face-centered cubic structure in the as-deposited state.

20 14. The multilayer coating system according to claim 1, characterized in that the outermost layer is an Al-Cr-B-N layer that exhibits the formation of B_xN_y , wherein x and y are atomic fractions of B and N, respectively.

15. A solid body at least partially coated with a multilayer coating system according to claim 1.

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16. The solid body according to claim 15 characterized in that the solid body is a cutting tool or a forming tool or a stamping tool, or a component or a part of a vehicle, or a component or part to be used in the motor industry or aerospace industry.

17. The multilayer coating system according to claim 1, wherein the hardness of the multilayer coating system is larger or equal to the hardness of the corresponding analogical Al-Cr-B-N monolayer coating.

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18. The multilayer coating system according to claim 1, wherein the coating portion where the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other contains at least three Ti-Al-N and three Al-Cr-B-N individual layers.

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19. The multilayer coating system according to claim 9, wherein the Al-Cr-B-N and Ti-Al-N individual layers are deposited alternately one on each other.

20. The multilayer coating system according to claim 1, wherein the overall coating thickness of the multilayer coating system is equal or thicker than 5 μm .