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(72) Inventors:
• **Berglund, Tomas**
SE-791 93 FALUN (SE)
• **Maderud, Carl-Johan**
SE 112 53 Stockholm (SE)
• **Meurling, Fredrik**
806 28 GÄVLE (SE)

(71) Applicant: **Sandvik Intellectual Property AB**
811 81 Sandviken (SE)

(54) **A method for manufacturing a wear resistant component comprising mechanically interlocked cemented carbide bodies**

(57) A method for manufacturing a wear resistant component (100) comprising the steps:
- providing a metallic base material (1) and a wear resistant cemented carbide body (2) which comprises an anchoring portion (4), which is adopted to be retained mechanically by the metallic base material ;
- arranging the wear resistant cemented carbide body (2) such that the anchoring portion (4) at least partially is

enclosed by the metallic base material (1);
- subjecting the metallic base material (1) and the least one wear resistant cemented carbide body (2) to HIP;

wherein the method comprises the step of arranging a layer (5) comprising (Al₂O₃) or (hBN) between the anchoring portion (4) the metallic base material (1).

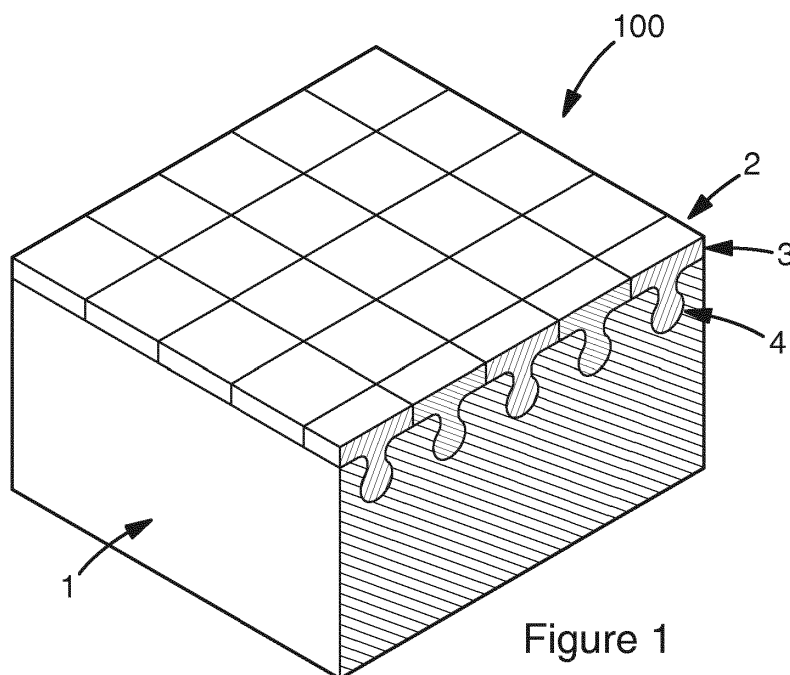


Figure 1

Description

TECHNICAL FIELD

[0001] The present invention relates to a method for manufacturing a wear resistant component by Hot Isostatic Pressing according to the preamble of claim 1. The invention also relates to a wear resistant component according to the preamble of claim 15.

BACKGROUND ART

[0002] Hot Isostatic Pressing (HIP) is a method which is very suitable for Net Shape manufacturing of individual components. In HIP a capsule which defines the final shape of the component is filled with a metallic powder and subjected to high temperature and pressure whereby the particles of the metallic powder bond metallurgically, intergranular voids are closed and the material is consolidated. The main advantage of the method is that it produces components of final, or close to final, shape having strengths comparable to forged material.

[0003] The HIP method may be used for manufacturing wear resistant components. For example, tube bends or impellers for transporting sand or sand/water slurries. The wear resistance of the component may thereby be increased by mixing hard particles, such as tungsten carbide powder, in the metallic powder from which the component is manufactured.

[0004] However, a drawback with this approach is that the toughness of the component decreases with increasing amounts of tungsten carbide. This may in turn result in low impact strength of the component. A further drawback is the unnecessary high material cost connected to manufacturing the entire composite component from a mixture of cemented carbide and metallic powder.

[0005] To increase the wear resistance of components attempts have been made to integrate cemented carbides bodies in components made of steel or cast iron. Cemented carbide bodies consist of a large portion hard particles and a small binder phase and are thus very resistant to wear.

[0006] However, due to formation of brittle phases such as M_6C -phase (a.k.a. eta-phase) and W_2C -phase in the interface between the cemented carbide body and the surrounding steel these attempts have not been successful. The M_6C -phase cracks easily under load and the cracks may propagate into the cemented carbide bodies and cause these to fail with decreased wear resistance of the component as a result.

[0007] It is an object of the present invention to provide a method which remedies at least one of the above mentioned drawbacks of prior art.

[0008] In particular, it is an object of the present invention to provide a method that allows for manufacturing of components having high wear resistance. A further object of the present invention to provide a method which allows for manufacturing, by Hot Isostatic Pressing, of

wear resistant components in which cemented carbide bodies are securely retained with no or very little formation of brittle phases. Yet a further object of the present invention is to provide a method which allows for cost effective manufacturing of wear resistant components.

SUMMARY OF THE INVENTION

[0009] According to a first aspect of the invention at least one of the above objects is achieved by a method for manufacturing a wear resistant component (100) comprising the steps:

- providing a metallic base material (1) and at least one wear resistant cemented carbide body (2), wherein the cemented carbide body (2) comprises a top portion (3) which is adopted to extend over at least a section of the surface of the metallic base material (1) and an anchoring portion (4) which is adopted to be retained mechanically by the metallic base material (1) in the final wear resistant component (100);
- arranging the wear resistant cemented carbide body (2) such that the top portion (3) extends over at least a section of the surface of the metallic base material (1) and such that the anchoring portion (4) at least partially is enclosed by the metallic base material (1);
- sealing the arrangement of the wear resistant cemented carbide body (2) and the metallic base material (1);
- subjecting the metallic base material (1) and the least one wear resistant cemented carbide body (2) to Hot Isostatic Pressing by heating at a predetermined temperature and at a predetermined pressure for a predetermined time period;

characterized in the step of arranging a layer (5) which comprises Al_2O_3 and/or hBN between at least the anchoring portion (4) of the wear resistant cemented carbide body (2) and the metallic base material (1).

[0010] Experiments have surprisingly shown that when a layer of Al_2O_3 (alumina) or a layer of hBN (hexagonal boron nitride) is arranged between the wear resistant cemented carbide body and the metallic base material, no brittle M_6C -phase is formed between the cemented carbide body and the metallic base material during HIP of the component. There is therefore no risk that the cemented carbide body will crack during operation and cause failure of the component. Due to the fact that the cemented carbide body is retained mechanically in the base material of the component it is prevented from being knocked out or pulled away from the component, even under very severe operational conditions.

[0011] The reason behind the minimized formation of brittle M_6C -phase may be explained as follows.

[0012] The HIP process takes place at high pressures and a high temperature and achieves thereby a metallurgical bond between surfaces of the cemented carbide body and the metallic base material. The metallurgical bond may be described as a flawless interface between the cemented carbide body and the metallic base material free of any pores, oxides or films. The surfaces of the cemented carbide body and base material adhere fully to each other at the interface and essentially form a homogenous body. The forming of the metallurgical bond takes place under various diffusion processes whereby, amongst other things, alloy elements diffuse between the wear resistant body and the metallic base material.

[0013] It is believed that under these conditions, the carbides in the surface of the cemented carbide body (e.g. tungsten carbide) dissolves and forms a complex phase, M_6C -phase or η -phase with alloy elements in the metallic base material and dissolved tungsten.

[0014] Further advantages of the inventive method is that it allows for selective wear protection of components. This since only areas which are subjected to wear are provided with cemented carbide bodies. This allows for reduced manufacturing costs.

[0015] A further advantage is that the properties, e.g. the mechanical properties, of the component may be tailored to suit a particular application by selecting specific materials for the body of the component and specific materials for the wear resistant cemented carbide bodies.

[0016] Further alternatives and embodiments of the present invention are disclosed in the dependent claims and the following detailed description.

BRIEF DESCRIPTION OF DRAWINGS.

[0017]

Figure 1 shows schematically a perspective view of a wear resistant component manufactured with the inventive method.

Figures 2a -2d shows schematically wear resistant cemented carbide bodies used in the inventive method.

Figures 3a and 3b shows schematically steps of the inventive method according to a first alternative.

Figures 4a - 4c shows schematically steps of the inventive method according to a second alternative.

Figure 5, shows schematically a component manufactured according to the first or the second alternative of the inventive method.

Figures 6 and 7 shows SEM-pictures of a sample of a component manufactured with the inventive method using a layer of Al_2O_3 .

Figures 8, 9 and 10 - 12 shows SEM-pictures of samples of components manufactured with the inventive method using a layer of hBN.

Figure 13 and 14 show SEM-pictures of samples from a comparative example.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Figure 1 shows schematically a wear resistant component 100 manufactured with the inventive method. In figure 1, the wear resistant component 100 is a brick for cladding a Grouser bar. However, the wear resistant component could have any form. For example, the wear resistant component may be a pipe, or crushing equipment such as an impact hammer or a crusher tooth, or slurry handling equipment or mineral handling equipment.

[0019] The wear resistant component 100 comprises a body 1 which consists of metallic base material. The metallic base material may any type of metallic material which is suitable to form the main structural body of the component in question. For example, the metallic base material may be a steel alloy, for example an iron based steel alloy, or a nickel based steel alloy or a cobalt based steel alloy. Preferably the metallic base material is a ferritic steel alloy such as a ferritic iron based steel alloy, for example the commercially available steel 410L. Ferritic steels have low coefficient of thermal expansion, which minimizes stress in the metallic base material during cooling from the HIP temperature. The metallic base material may also comprise hard particles in order to increase the overall hardness or strength of the component, for example the metallic base material may be Metal Matrix Composite (MMC).

[0020] Wear resistant cemented carbide bodies 2 are arranged on a surface of the component which is to be protected against wear, such as protection from abrasive wear, erosive wear, impacts or corrosion. The wear resistant bodies 2 have a top portion 3 which extends over a section of the surface of the body 1 of metallic base material. The cemented carbide bodies 2 further have an anchoring portion 4 which protrudes from the top portion 3. The anchoring portion 4 is enclosed by the metallic base material and is, as will be further described below, due to its design locked mechanically in the metallic base material.

[0021] The number and shape of the wear resistant cemented carbide bodies depends on the type and shape of the component 100. Therefore, the component could comprise merely one wear resistant body or several wear resistant bodies such as two wear resistant bodies or any other number, for example 1000 wear resistant bodies.

[0022] The inventive method for manufacturing a wear resistant component 100 according to a first embodiment will in the following be described with reference to figures 2a-5.

[0023] In a first step, a wear resistant cemented car-

bide body 2 is provided. Figure 2a shows schematically a wear resistant body 2 which has a top portion 3 which is adopted to extend over at least a portion of the component in order to protect that portion of the component from wear.

[0024] The top portion 3 of the wear resistant cemented carbide body may have any shape suitable for protecting the underlying section of the component from wear. The top portion may for example be rectangular, or triangular or have any other geometrical form which allows several wear resistant bodies 2 to be placed adjacent each other such that their top portions 3 together form a continuous, unbroken surface. Typically, the upper surface of the top portion 3, i.e. which faces away from the anchoring portion 2 is flat, but depending of the field of application it may have other shapes, such as convex. Also the lower surface of the top portion 3, i.e. that faces the anchoring portion may have any shape, such as flat or convex or concave.

[0025] The wear resistant body 2 further comprises at least one anchoring portion 4 which protrudes from the top portion 3. The anchoring portion 4 protrudes from the lower side of the top portion 3 of the wear resistant body. In figure 2a, the anchoring portion 4 is in the form of an elongated profile and extends over the entire middle section of the top portion 3. However, it is obvious that the anchoring portion 4 may also only extend over a portion of the top portion 3 of the wear resistant body 2. An advantage with a profile shaped, elongated, anchoring portion is that the anchoring portion is retained very strong in the final component.

[0026] Figure 2b shows an alternative design of the wear resistant body 2. In this case, the anchoring portion 4 is a discrete, protruding element which protrudes like a stem from the center of the lower side of the top portion 3. The advantage thereof is that the top portion 3 covers the entire anchoring portion 4 and thus protects the anchoring portion from wear.

[0027] The anchoring portion is designed such that it will be mechanically locked in the consolidated metallic base material after HIP. In general, this may be achieved by designing the anchoring portion 4 so that the cross-section of the upper end of the anchoring portion (i.e. adjacent the top portion 3) is narrower than the cross-section of the lower end of the anchoring portion 4, i.e. distal from the top portion.

[0028] However, it is also possible to achieve a mechanical lock by designing the anchoring portion so that the cross-section of the middle of the anchoring portion may be thicker, or narrower than adjacent portions.

[0029] In figure 2a, the anchoring portion 4 is an elongated drop-shaped profile. In figure 2b the discrete anchoring portion 4 is drop-shaped. Both designs thereby achieve a mechanical lock in the final component.

[0030] Figure 2c and 2d shows alternative designs of the anchoring portion. For example, figure 2c, shows an anchoring portion 4, having projections 4b which extends perpendicular from the anchoring portion 4 and parallel

with the top portion 3 of the wear resistant body. Figure 2c shows a design in which the anchoring portion 4 forms a wall around a hollow space under the top portion 3. The bottom end of the wall is undercut.

[0031] The wear resistant body 2 is manufactured from sintered cemented carbide. The cemented carbide consist of 75 - 99%, preferably 90 - 95 %, of hard carbide particles, typically tungsten carbide (WC) and remainder binder phase such as cobalt. However, it may also consist of other carbides, such as TiC and other binder phase such as nickel or combinations of chromium, nickel and cobalt. The high amount of hard particles in the cemented carbide body provides a good wear protection on the surface of the component.

[0032] The wear resistant bodies 2 may be manufactured by molding a blend of carbide and binder powders into a green body with a desired shape and subsequently sintering of the green body in a sintering furnace. Sintering may take place at a temperature above the melting point of the binder material, which melts and during solidification cements the hard carbides into a rigid wear resistant body.

[0033] In a second step (not shown), a metallic base material 1 is provided. In the first alternative of the inventive method, the metallic base material is in the form of a volume of powder, for example a volume of powder having a particle size of 10-250 μm . However, as will be described further below, the metallic base material may also be a forged or a cast body. It is of course possible that the metallic base material is constituted by both powder and forged and/or cast bodies.

[0034] In a third step, see figures 3a and 3b, the wear resistant cemented carbide bodies 2 and the metallic base material 1 are arranged such that the top portions 3 of the wear resistant cemented carbide bodies 2 extends over at least a portion of the surface of the metallic base material 1.

[0035] Consequently, in the first alternative of the invention, in which the metallic base material at least partially is a powder, a capsule 10 which at least partially defines the shape of the component 100 is provided. The capsule 10, see figure 3a, is manufactured from steel sheets that are welded together. The capsule 10 may have any shape, in figure 3a the capsule defines the shape of a brick shaped component and has thus a bottom plate 11 and a circumferential wall 12. Wear resistant cemented carbide bodies 2 are placed in the capsule 10 so that the upper surface of the top portion 3 of the wear resistant bodies are supported on the bottom plate 11 of the capsule whereby the anchoring portion 4 protrudes in a direction towards the interior of the capsule.

[0036] In a subsequent step, see figure 3b the capsule 10 is filled with a powder of a metallic base material 1. The powder 1 thereby encloses the anchoring portion 4 of the wear resistant cemented carbide bodies and embeds the anchoring portions and the lower side of the top portion 3 of the wear resistant cemented carbide bodies 2. It is of course also possible to first fill the capsule with

a volume of powder and then placing the wear resistant bodies 2 on the surface of powder volume and pushing the anchoring portion into the powder. The wear resistant bodies can of course be arranged on any surface of the metallic base body.

[0037] Subsequently the capsule is sealed by a lid 13 which is welded to the circumferential wall of the capsule, see figure 3b.

[0038] According to a second alternative of the inventive method, the metallic base material is a forged or cast solid body 1, see figure 4a. The solid body 1 is provided with recesses 15, such as bores formed by drilling and/or milling, on a surface that shall be protected against wear. The wear resistant cemented carbide bodies 2 are arranged such the top portion 3 extends over the surface of the solid body of metallic base material and such that their anchoring portions 4 are inserted into the recesses 15 and thereby enclosed by metallic base material 1, see figure 4b. Subsequently, a lid 13 is placed over the wear resistant bodies 2 and welded to the metallic base body 1, see figure 4c. It is important to seal the arrangement of metallic base material and wear resistant bodies since the body of metallic material otherwise not will be compacted by the pressure in the HIP-chamber.

[0039] According to the invention, a layer 5 of Al_2O_3 (alumina) or hBN (hexagonal boron nitride) is arranged between at least the anchoring portion 4 and the metallic material which encloses the anchoring portion. Preferably, the layer of Al_2O_3 or hBN also extends between the metallic base material and the lower surface of the top portion 3 of the wear resistant body 2. More preferably, the layer of Al_2O_3 or hBN is arranged between all interfacing surfaces of metallic base material and wear resistant cemented carbide bodies. When the metallic base material is in the form of powder, the layer of Al_2O_3 or hBN is suitably applied on the wear resistant body, see figure 3a which shows a layer 5 that is applied on the anchoring portion 4 of the wear resistant cemented carbide body 2. However, when the metallic base material is a solid body, such as forged or cast, the layer of Al_2O_3 or hBN may be applied either on the surfaces of the metallic body or on the wear resistant body 2. Figure 4c show schematically a portion of a solid body, in which a layer 5 of Al_2O_3 or hBN has been applied on the surface of the recess 15.

[0040] As discussed earlier, the layer of Al_2O_3 or hBN will prevent metallurgical bonding between the wear resistant cemented carbide bodies and the metallic base material and thus also prevent the formation of brittle M_6C -phase.

[0041] The layer of Al_2O_3 or hBN may be applied by various methods.

[0042] Preferably, Al_2O_3 is applied by CVD (Chemical Vapour Deposition). This method is suitable for applying coatings on components with complex geometries. The method allows for high coating speed and many components may therefore be coated at the same time. A further advantage with CVD is that dense coatings are achieved

and the repeatability is high. Al_2O_3 may also be applied by plasma spraying, which is a suitable method for coating of large surfaces. It is also possible to apply the layer of Al_2O_3 by PVD (Physical Vapor deposition).

[0043] When the layer consists of Al_2O_3 , the thickness should be at least $2\text{ }\mu\text{m}$ in order to ensure that interfacing surfaces of wear resistant body and metallic base material does not come in contact with each other. The resistance to metallurgical bonding is believed to increase with increasing layer thickness. However, too thick layers may crack and therefore the thickness of Al_2O_3 layers should be $2\text{ }\mu\text{m} - 10\text{ }\mu\text{m}$, preferably $4\text{ }\mu\text{m} - 8\text{ }\mu\text{m}$.

[0044] In addition to preventing metallurgic bonding, a further advantage of a layer of Al_2O_3 is that Al_2O_3 has good adhesion to the underlying surface and is resistant to mechanical wear which makes components with Al_2O_3 layers easy to handle.

[0045] A layer of hBN may be applied by brushing or spraying a suspension of hBN, a binder, such as a solgel and a solvent, such as ethanol or water, onto the wear resistant body. It is also possible to apply the hBN layer onto the wear resistant body by dipping the wear resistant body in the suspension. To achieve a layer of suitable thickness the wear resistant body need to be sprayed, painted or dipped several times. Between each application, the wear resistant body may be allowed to dry for at least 10 minutes in room temperature. The drying time must be adjusted in dependency of the solvent since, for example ethanol, evaporates faster than water. A suitable solution of hBN and solvent is for example MYCRO-NID® BORON NITRIDE SUSPENSION which is available commercially from ESK Ceramics GmbH & Co. KG.

[0046] When the layer consist of hBN, the thickness should be at least $20\text{ }\mu\text{m}$ in order to ensure that interfacing surfaces of wear resistant body and metallic base material does not come in contact during HIP. However, too thick layers, may result in that the wear resistant bodies are not sufficiently retained in the metall base material. A further disadvantage with thick layers is that the adhesion of thick layers to the base material is poor. Therefore, the thickness of hBN layers should be $20\text{ }\mu\text{m} - 100\text{ }\mu\text{m}$, preferably $50\text{ }\mu\text{m} - 80\text{ }\mu\text{m}$.

[0047] An additional advantage with a layer of hBN is that due to its low friction coefficient the hBN layer allow relative motion between the metal and the cemented carbide as well as reduce stresses in the interface otherwise arising from the thermal elongation mismatch between the metal and the cemented carbide.

[0048] It is also possible to apply a layer of TiC on the surface of the wear resistant body prior to application of the layer of Al_2O_3 . The layer of TiC may for example be $5 - 10\text{ }\mu\text{m}$ and increases the adhesion between the cemented carbide and the Al_2O_3 coating.

[0049] In a further step, (not shown) the sealed arrangement of metallic base material and wear resistant cemented carbide bodies, are subjected to Hot Isostatic Pressing (HIP) at a predetermined temperature, a predetermined isostatic pressure and a for a predetermined

time so that the metallic base material closes around the anchoring portions of the wear resistant bodies and lock thereby these mechanically in the component. The capsule is thereby placed in a heatable pressure chamber, normally referred to as a Hot Isostatic Pressing-chamber (HIP-chamber).

[0050] The heating chamber is pressurized with gas, e.g. argon gas, to an isostatic pressure in excess of 500 bar. Typically the isostatic pressure is 900 - 1200 bar. The chamber is heated to a temperature which is below the melting point of the metallic base material. The closer the temperature is to the melting point, the higher is the risk for the formation of melted phase and unwanted streaks of brittle carbide. Therefore, the temperature should be as low as possible in the furnace during HIP:ing. However, at low temperatures the diffusion process slows down and the material will contain residual porosity and the metallurgical bond between individual particles or pieces of metallic base material becomes weak. Therefore, the temperature is 900 - 1150°C, preferably 1000 - 1150°C. The arrangement of metallic base material and cemented carbide bodies is held in the heating chamber at the predetermined pressure and the predetermined temperature for a predetermined time period. The consolidation processes that take place between the metallic materials during HIP:ing are time dependent so long times are preferred. Preferable, the form should be HIP:ed for a time period of 0.5 - 3 hours, preferably 1 - 2 hours, most preferred 1 hour.

[0051] During HIP:ing the metallic base material deforms plastically around the anchoring portions of the wear resistant bodies and lock thereby these mechanically in the component. Metallic base material which is not coated with Al₂O₃ or hBN bond metallurgically through various diffusion processes and internal voids are closed so that a dense, coherent component is achieved. Figure 5 shows a HIP:ed component consisting of a solid body 1 of metallic base material and wear resistant bodies that are mechanically locked in the metallic base material.

[0052] After HIP:ing the lid and, if present, the capsule may be partly or completely stripped from the consolidated component by e.g. machining or grit blasting.

EXAMPLE

[0053] The present invention will in the following be described with reference to two nonlimiting concrete examples performed by the inventive method and one comparative example.

[0054] In a first test (Test 1), the effect of a coating of alumina (Al₂O₃) on a cemented carbide body was investigated. In a second test (Test 2), the effect of coatings of hexagonal boron nitride (hBN) on cemented carbide bodies was investigated. In a third test (Comparative Test) a non-coated cemented carbide body was embedded in steel powder and HIP:ed.

Test 1 - Al₂O₃ coating on cemented carbide

[0055] Firstly a cemented carbide test body having a 5 μm thick TiC coating closest to the cemented carbide surface and an outermost 5 μm thick coating of Al₂O₃ was provided. For this purpose a cutting insert was used. The insert had the dimensions 2 x 2 x 0.5 (cm). The coatings were applied with CVD.

[0056] Figure 6 shows a Scanning Electron Microscope (SEM) image of the cemented carbide body 2 which consisted of two different types of hard particles 2a and 2b and a binder phase 2c. The chemical composition of the cemented carbide body was determined in the SEM. The first type of hard particles 2a was identified as tungsten carbide. The second type of hard particles 2b consisted of carbides of tungsten, Ti and Nb. The binder phase 2c consisted of mainly cobalt with a small addition of nickel.

[0057] The cemented carbide body was embedded in commercially available 410L steel powder in a capsule of steel sheets that had been welded together. The 410L powder had the following composition:
C: 0.023, Si: 0.52, Mn: 0.20; P 0.009, S: 0.008; Cr: 13.0; Ni: 0.27, balance Fe.

[0058] The steel powder had the following Sieve analysis according to ASTM-E11:

Micron:	355	300	212	125	53
Mesh:	45	50	70	120	270
%<	100	94	76	47	8

[0059] The capsule was sealed by welding and subjected to Hot Isostatic Pressing (HIP) at a temperature of 1150°C, at a pressure of 1000 bar. The capsule was held at this temperature and pressure for two hours and then allowed to cool down with a cooling rate of approximately 3-5°C /min.

[0060] After HIP:ing the capsule was cut through the center of the cemented carbide body and samples were taken for analysis. The samples were prepared by polishing for analysis by scanning electron microscopy (SEM) which was performed in a Zeiss EVO 50 VPSEM.

[0061] Figure 7 shows a SEM image of the interface between the surface zone of the cemented carbide body 2 and the surrounding steel matrix 1. The layer closest to the surface of the cemented carbide body is TiC. The outermost layer, 5 is Al₂O₃.

[0062] As can be seen in figure 7, there is no evidence of metallurgical binding in the interface between the Al₂O₃ layer 5 on the cemented carbide body 2 and the surrounding steel matrix 1. Nor are there any traces of any reaction phase, e.g. M₆C-carbides due to diffusion of elements between the cemented carbide and the steel matrix. A void 6 is clearly visible between the outermost layer of Al₂O₃ and the adjacent steel matrix. The void is approximately 2-3 μm wide and is believed to be formed when the steel matrix and the cemented carbide shrinks

during cooling from the HIP temperature.

Test 2 - hBN coating on cemented carbide body

[0063] In a second test two cemented carbide cutting inserts were coated with a suspension of hexagonal boron nitride (hBN). The solution used was Mycronide® boron nitride suspension from the company Ceradyne/ESK. The suspension contained a solid content of $\leq 18\%$ BN in a liquid phase of ethanol and a reactive solgel binder.

[0064] Firstly, the chemical composition of the cemented carbide insert in uncoated condition was investigated in the SEM, see figure 8. The cemented carbide insert consists of three different phases 1a, 1b and 1c. The three different phases were identified as: 1a=(W, Ti)C, 1b=(W, Ti, Ta)C and 1c=WC. The hard phase particle size was roughly $3\text{ }\mu\text{m}$ and below. The binder phase consisted mainly of cobalt but with an addition of chromium.

[0065] The inserts were dipped eight times each in the hBN solution. Between each dipping the inserts were allowed to dry for 30 minutes in room temperature.

[0066] The coating on the first insert was hardened at a temperature of 300 for 30 minutes after the final dipping.

[0067] The coating on the second insert not hardened instead it was only allowed to dry in room temperature for 30 minutes between each dipping.

[0068] Thereafter the two cemented carbide cutting inserts were embedded in 410L steel powder in a capsule and subjected to HIP as described in Test 1. After HIP:ing the capsule was cut through the center of the cemented carbide body and samples from both inserts were taken and prepared for analysis as described in Test 1.

[0069] Figure 9 shows a SEM image of a sample from the first cemented carbide cutting insert. As can be seen in the image there is a void 6, i.e. the black area between the steel matrix 1 and the surface of the cutting insert 2. The void results from the hBN coating that was removed during sample preparation. As can be seen, the void is of uniform cross-section and approximately $20\text{ }\mu\text{m}$ thick. On some occasions there are "bridges" between the steel matrix and the surface of the cemented carbide insert. The "bridges" are believed to be formed by steel powder that penetrates through cracks in the hBN coating. The cracks may have been formed due to that the coating becomes brittle during hardening. A reaction zone is formed between steel and cemented carbide at the end of the "bridge". However, the "bridges" are relatively few and narrow and have therefore no significant negative effect on the mechanical interlocking attachment of the cemented carbide insert in the steel matrix.

[0070] Figure 10 shows a SEM image of a sample from the second cemented carbide cutting insert. Also in this sample the hBN coating has been removed during preparation of the samples and left a void 6 between the steel matrix 1 and the cemented carbide insert 2. Figure 11 is an enlargement of a portion of the image in figure 10. Figure 12 is a 1000 times magnification of figure 10, it is clearly visible that no reaction zone has formed where

the hBN layer has separated steel powder and cemented carbide insert.

[0071] From figures 11 and 12 it is visible that particles of the steel powder have penetrated into the hBN coating during HIP. This is possible, since the hBN coating on the second cutting insert only has been dried in room temperature between applications and therefore is softer than the hardened coating on the first sample.

Test 3 - Comparative test with uncoated cemented carbide insert

[0072] In a third test an uncoated cemented carbide insert was embedded in 410 L steel powder in a capsule and subjected to HIP under the same conditions as the coated inserts in the first and the second tests.

[0073] The chemical composition of the uncoated cemented carbide insert was identical to the chemical composition of the inserts used in Test 2.

[0074] After HIP:ing the capsule was cut through the center of the uncoated cemented carbide body and samples were taken and prepared for analysis as described in Test 1 and Test 2. Figure 13 shows a SEM-image of a sample from the HIP:ed uncoated cemented carbide insert.

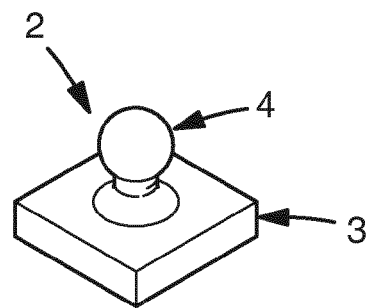
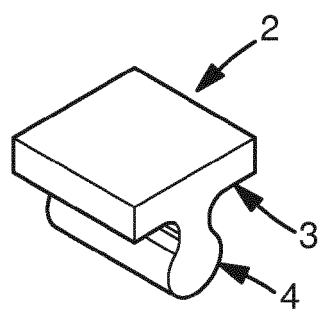
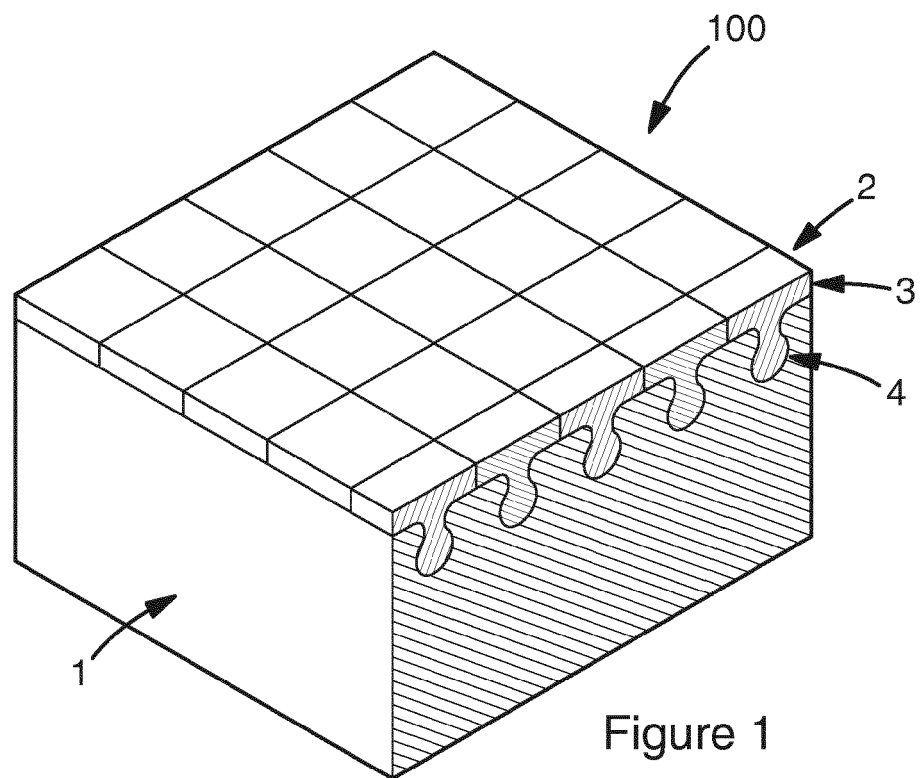
[0075] As can be seen in figure 13, the uncoated cemented carbide insert 2 is metallurgically bound to the surrounding 410L steel matrix 1 and a reaction zone 7 of brittle carbide phases is formed in the outermost part of the cemented carbide insert 2. The chemical composition of the reaction phase 7 is shown in figure 14.

Claims

1. A method for manufacturing a wear resistant component (100) comprising the steps:

- providing a metallic base material (1) and at least one wear resistant cemented carbide body (2), wherein the cemented carbide body (2) comprises a top portion (3) which is adopted to extend over at least a section of the surface of the metallic base material (1) and an anchoring portion (4) which is adopted to be retained mechanically by the metallic base material (1) in the final wear resistant component (100);
- arranging the wear resistant cemented carbide body (2) such that the top portion (3) extends over at least a section of the surface of the metallic base material (1) and such that the anchoring portion (4) at least partially is enclosed by the metallic base material (1);
- sealing the arrangement of the wear resistant cemented carbide body (2) and the metallic base material (1);
- subjecting the metallic base material (1) and the least one wear resistant cemented carbide

- body (2) to Hot Isostatic Pressing by heating at a predetermined temperature and at a predetermined pressure for a predetermined time period; **characterized in** the step of arranging a layer (5) which comprises alumina (Al_2O_3) or hexagonal boron nitride (hBN) between at least the anchoring portion (4) of the wear resistant cemented carbide body (2) and the metallic base material (1).
2. The method according to claim 1, wherein the layer (5) is applied on at least the anchoring portion (4) of the wear resistant cemented carbide body (2).
 3. The method according to claim 1 or 2, wherein the layer (5) is applied on the metallic base material (1).
 4. The method according to any of claims 1 - 3, wherein the layer (5) consists of alumina (Al_2O_3) or hexagonal boron nitride (hBN).
 5. The method according to any of claims 1 - 4, wherein the layer (5) consists of Al_2O_3 and wherein an intermediate layer comprising Ti is arranged between the Al_2O_3 layer (5) and the surface of the wear resistant cemented carbide body (2).
 6. The method according to claim 5, wherein the intermediate layer is TiC.
 7. The method according to any of claims 4- 6, wherein the layer (5) consists of Al_2O_3 , wherein the thickness of the layer (5) is 2 μm - 10 μm , preferably 4 μm - 8 μm .
 8. The method according to any of claims 1 - 4, wherein the layer (5) consists of hBN wherein the layer (5) has a thickness of 20 μm - 100 μm , preferably 50 μm - 80 μm .
 9. The method according to claim 4 or 8, wherein the hBN layer (5) is applied as a suspension comprising hBN powder and solvent, wherein the suspension is applied by dipping or spraying or brushing.
 10. The method according to any of claims 1-9, wherein the anchoring portion (4) of the wear resistant cemented carbide body is of drop shaped cross-section.
 11. The method according to any of claims 1-10 wherein the metallic base material (1) is an iron based alloy or a cobalt based alloy or a nickel based alloy or a Metal Matrix Composite (MMC).
 12. The method according to any of claims 1-11 wherein the metallic base material (1) is an iron based ferritic steel alloy.
 13. The method according to any of claims 1-12, wherein the metallic base material (1) is a cast and/or forged body, wherein at least one recess 15 is formed in the metallic base material, wherein the anchoring portion (4) of the wear resistant cemented carbide body (2) is arranged in the recess 15.
 14. The method according to any of claims 1-12, the metallic base material is powder, wherein the anchoring portion (4) of the wear resistant cemented carbide body (2) is arranged such that the anchoring portion (4) at least partially is enclosed by metallic base material powder.
 15. A wear resistant component (100) comprising a metallic base material (1) and at least one wear resistant cemented carbide body (2) obtained by the method according to any of claims 1 - 14, **characterized by** a void (6) that extends along an interface between cemented carbide body (2) and the metallic base material (1).



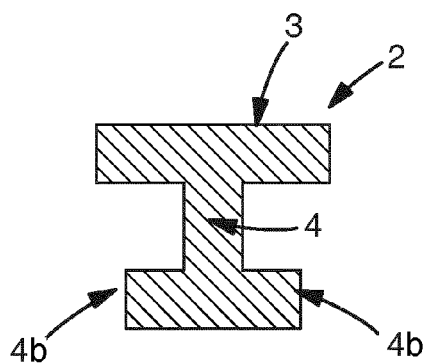


Figure 2c

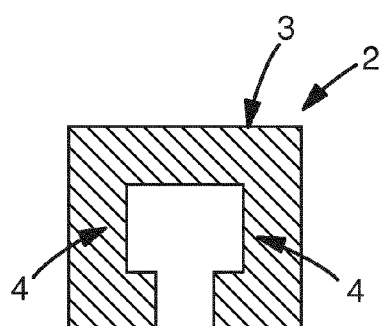


Figure 2d

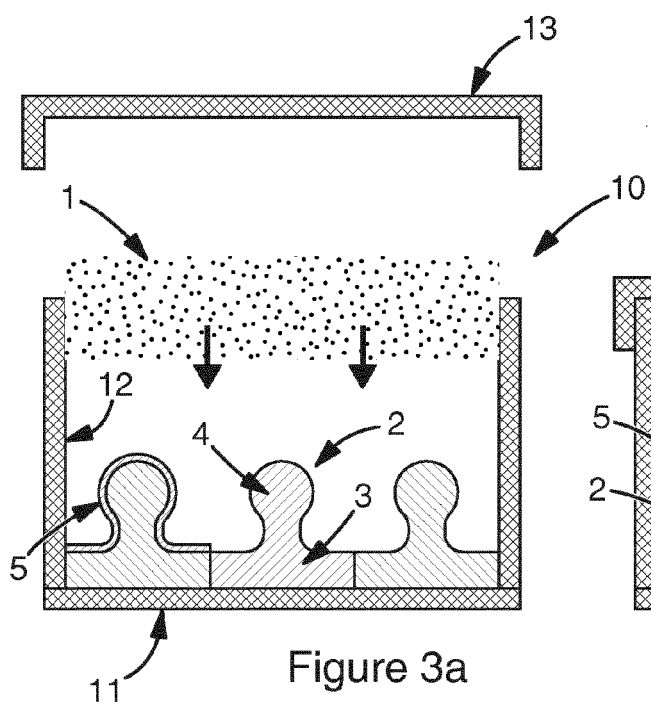


Figure 3a

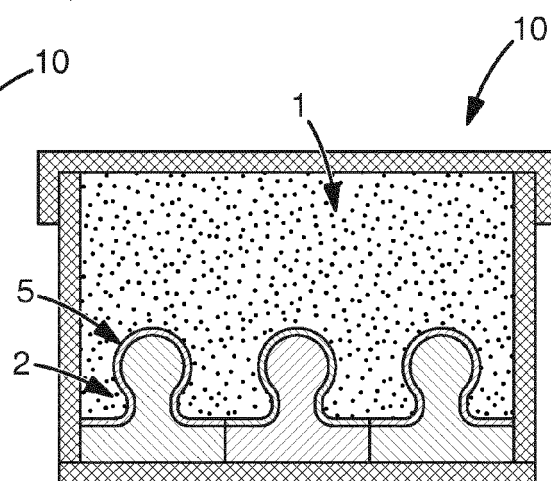


Figure 3b

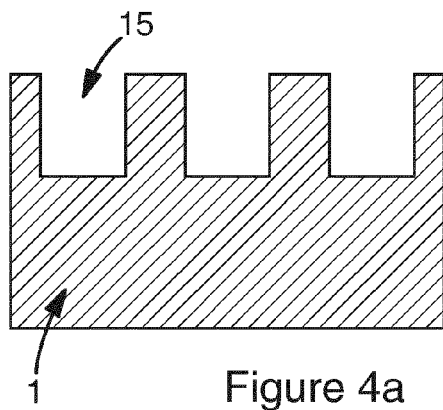


Figure 4a

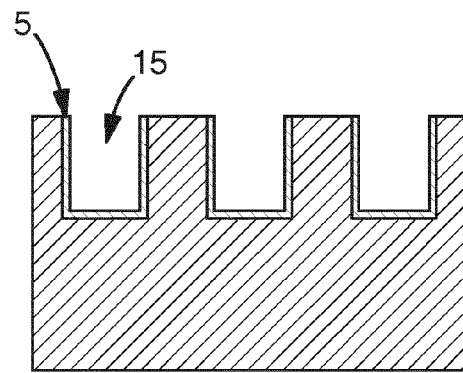


Figure 4b

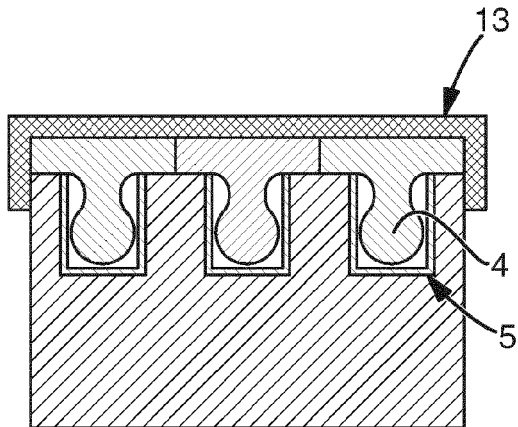


Figure 4c

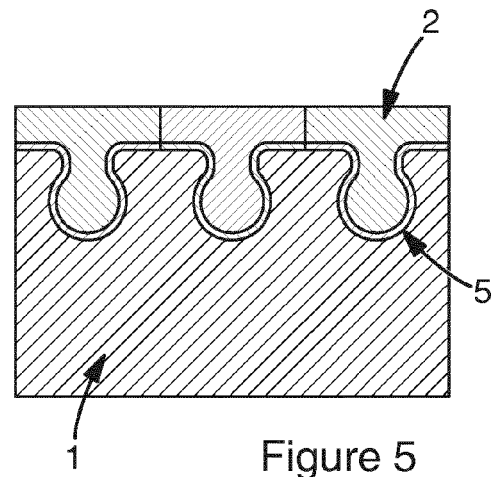


Figure 5

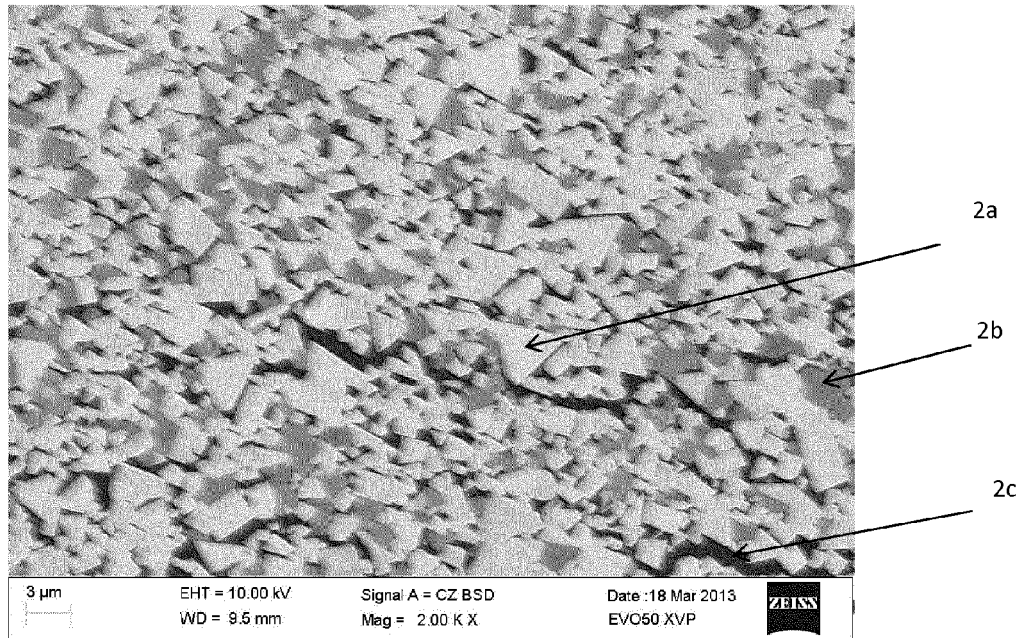


Figure 6

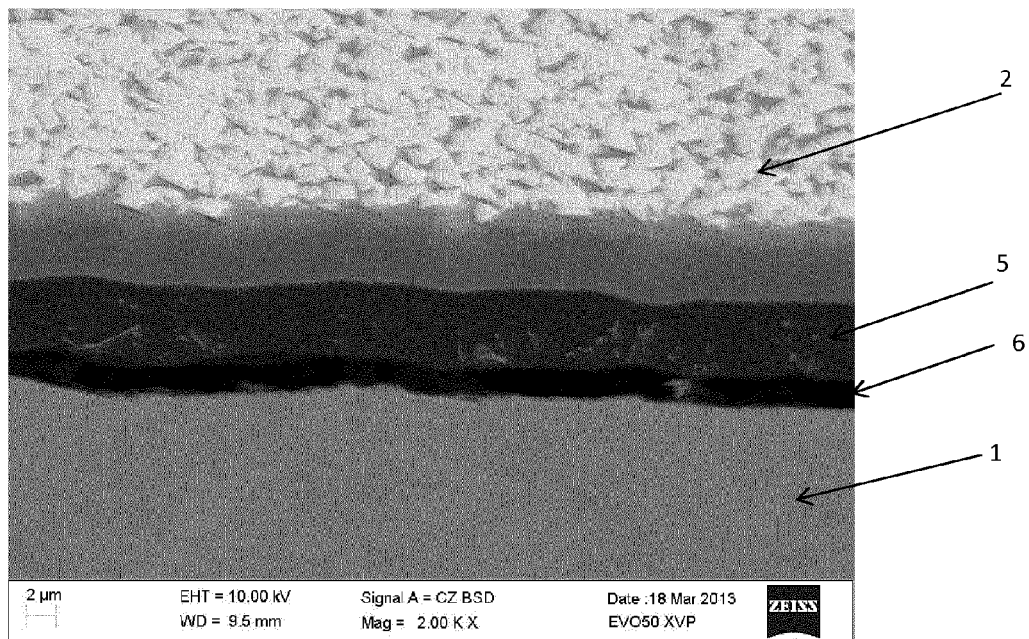


Figure 7

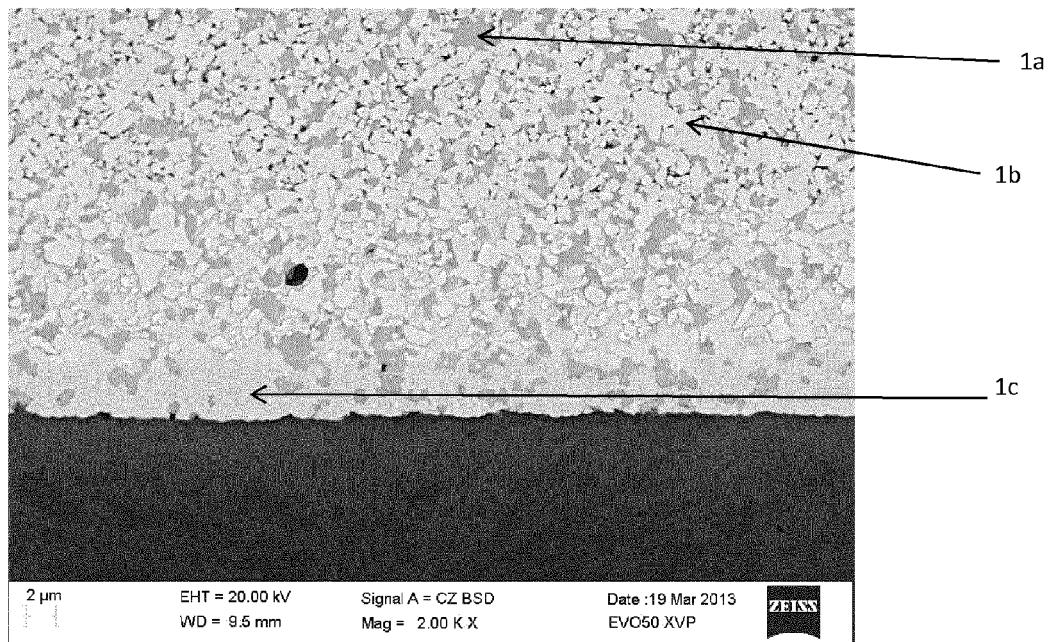


Figure 8

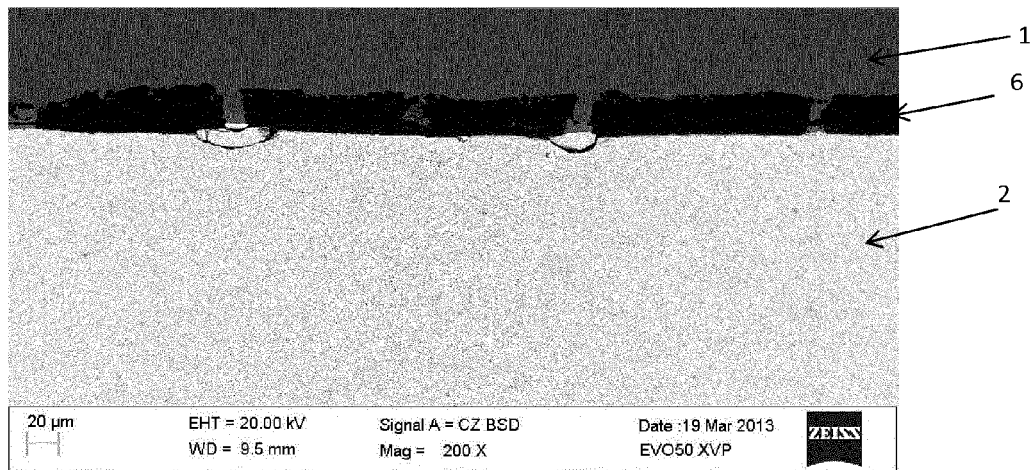


Figure 9

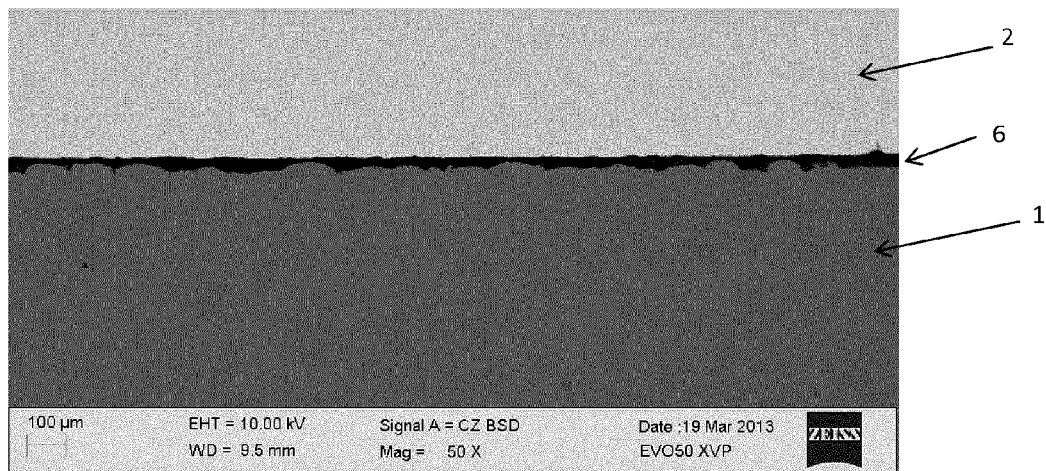


Figure 10

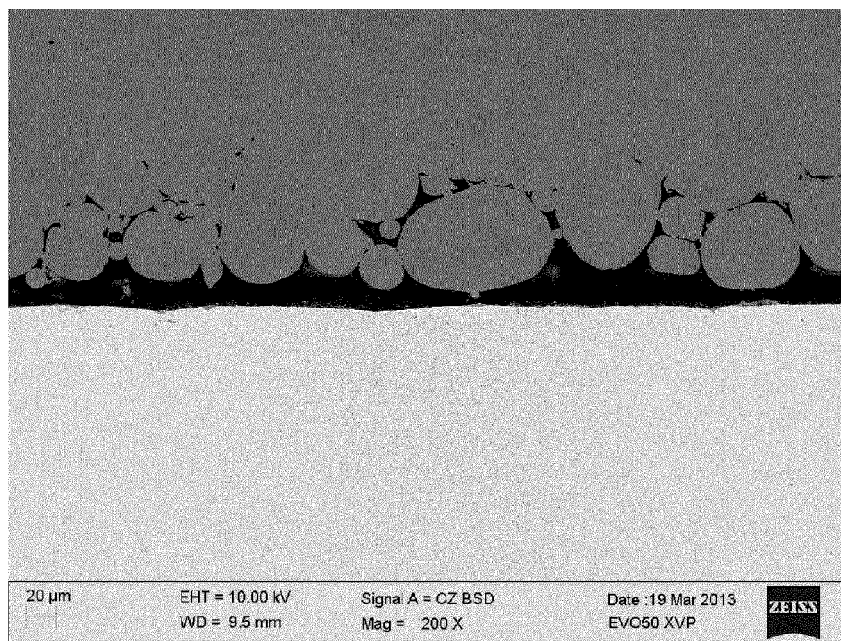


Figure 11

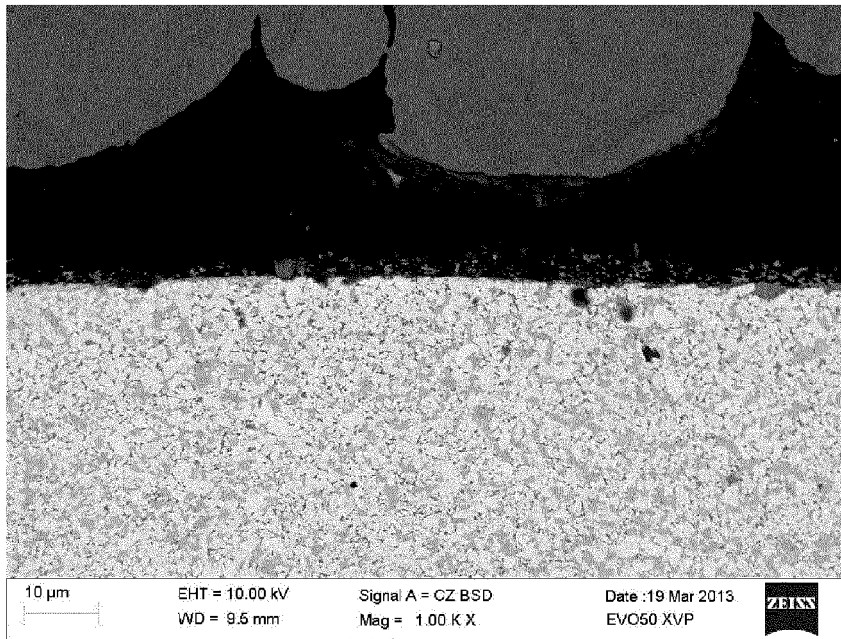


Figure 12

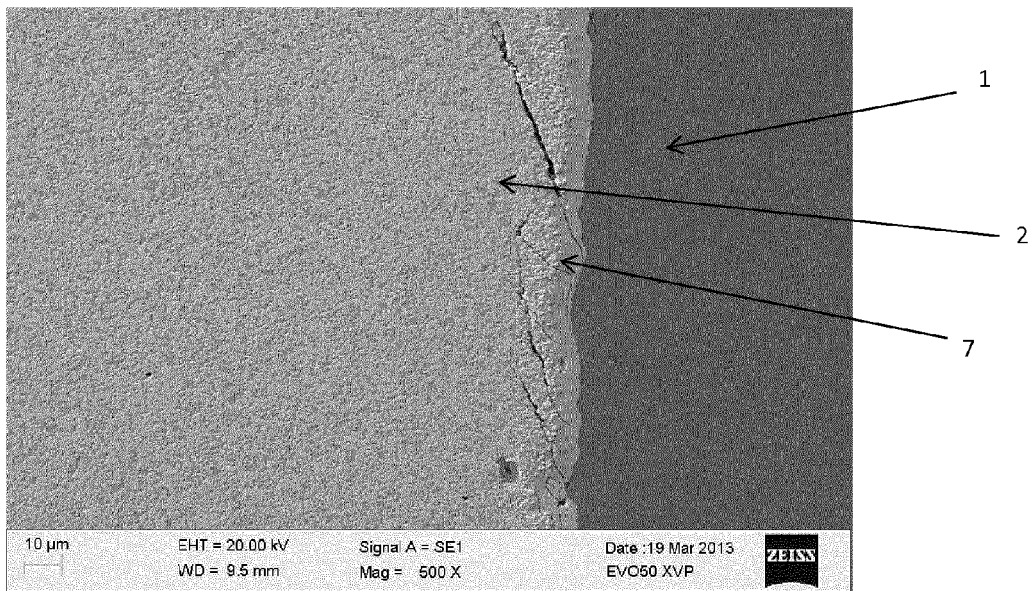


Figure 13

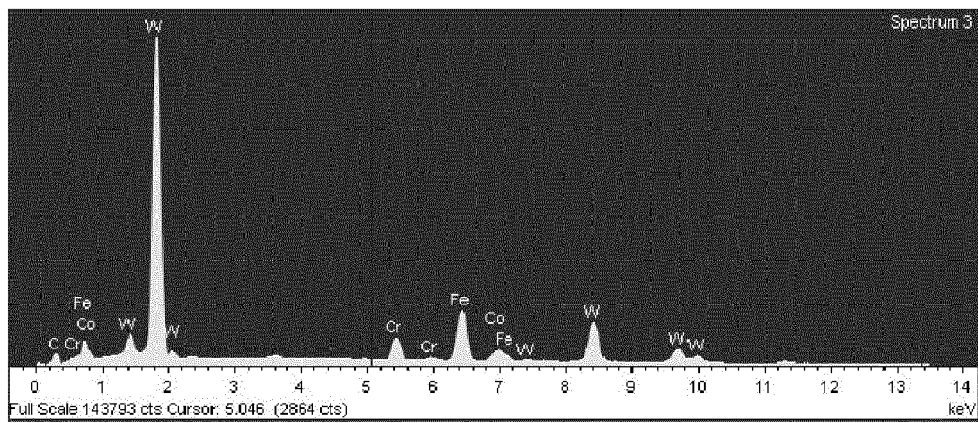


Figure 14



EUROPEAN SEARCH REPORT

Application Number
EP 13 17 5106

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 0 169 718 A2 (CDP LTD [US]) 29 January 1986 (1986-01-29) * page 4, line 20 - page 6, line 22 * * page 8, line 7 - page 9, line 15 * * page 9, line 17 - page 10, line 25 * * page 14, line 25 - page 17, line 20 * * claims; figures; examples * -----	1-15	INV. B22F7/06 B22F7/08 B62D55/00 C22C29/06
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A	GB 1 174 624 A (FEDERAL MOGUL CORP [US]) 17 December 1969 (1969-12-17) * the whole document * -----	1,15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			C22C B22F B62D
Place of search		Date of completion of the search	Examiner
The Hague		9 December 2013	Ceulemans, Judy
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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The members are as contained in the European Patent Office EDP file on
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