There is provided a method for applying a diffusion coating on a specific area of targeted industrial item such as a turbine blade. The method uses a covering material such as a tape or slurry to cover the area where it is desired that the diffusion occur, for example above the root area of a turbine blade. The tape material includes a metallic source such as chromium and a master alloy of active elements for diffusion. The covering material thus defines the localized patch that is to be coated. An activator if any, such as a halide activator, can be included in the tape or slurry. Alternatively, the activator can be included in the pack material. The method uses known pack cementation methods to complete the diffusive process. The method results in a diffusion coating over a specific area of the target item.
T-1555 – 3 LAYERS. Mar M 247 SUBSTRATE. AG 21 ETCHANT

T-1558 – 1 LAYER. Mar M247 SUBSTRATE. AG 21 ETCHANT

FIG. 4
FIG. 6
ACTIVE ELEMENTS MODIFIED CHROMIUM DIFFUSION PATCH COATING

FIELD OF THE INVENTION

[0001] The present invention relates to methods and materials for forming a protective diffusion layer on metallic items. More particularly the invention relates to a method for applying an active elements modified chromium diffusion layer coating on a specific area of an item, such as between the serrations and platform on a turbine blade, without diffusing coating material into other areas of the item.

BACKGROUND OF THE INVENTION

[0002] In an attempt to increase the efficiencies and performance of contemporary jet engines, and gas turbine engines generally, engineers have progressively pushed the engine environment to more extreme operating conditions. The harsh operating conditions of high temperature and pressure that are now frequently specified place increased demands on engine components and materials. Indeed the gradual change in engine design has come about in part due to the increased strength and durability of new materials that can withstand the operating conditions present in the modern gas turbine engine.

[0003] The turbine blade is one engine component that directly experiences severe engine conditions. Turbine blades are thus designed and manufactured to perform under repeated cycles of high stress and high temperature, as well as under corrosive atmospheres. An economic consequence of such a design criteria is that currently used turbine blades can be quite expensive. It is thus highly desirable to maintain turbine blades in service for as long as possible. It is correspondingly desirable to manufacture and finish turbine blades so as to withstand the corrosive and erosive forces that will attack turbine blade materials.

[0004] Turbine blades used in modern jet engines are frequently castings made from a class of materials known as superalloys. The superalloys include alloys with high levels of nickel and/or cobalt. In the cast form, turbine blades made from superalloys include many desirable physical properties such as high strength. Advantageously, the strength displayed by this material remains present even under stressful conditions, such as high temperature and high pressure. Disadvantageously, the superalloys generally can be subject to corrosion and oxidation at the high temperature operating regime. Sulfidation can also occur in those turbine blades subject to hot exhaust gases.

[0005] Thus, it has become known to provide coatings or protective layers on items, such as turbine blades, that are subject to corrosion, erosion or sulfidation. Chromium, aluminum, and other metallic coatings can be used to provide a protective layer that is more resistant to corrosion and/or oxidation than is the underlying substrate material. In the case gas turbine engine components made out of superalloys, materials such as platinum, aluminum, and chromium can be used to provide protective diffusion coatings.

[0006] One method used for providing diffusion coatings is the pack cementation process. In this method the target, the industrial item to be coated, is placed in a box or retort with a “pack” surrounding it. The pack typically includes a source of the metal that is to be diffused into the target, inert packing material, and an activator. Typically the target lies in a bed of powdered materials. The box containing the target and its surrounding pack is then placed in an oven where the materials are heated for desired periods of time at desired temperature ranges. Diffusion takes place during the heat treating thermal cycle process. Pack cementation is a comparatively attractive method of coating in that it is a relatively simple method that is relatively inexpensive to apply to the target, as compared to other methods of coating superalloys.

[0007] The damage caused by oxidation, hot corrosion, and erosion, due to the flowing of hot combustion gases often establishes the operating lives of jet engine components such as blades and vanes. Hence the components are coated with various types of coatings to meet and extend the operating lives of parts. Thus the high pressure turbine (HPT) blades and vanes generally utilize aluminiides and platinum modified aluminiides for oxidation resistance. In the low pressure stages, chromium diffusion coatings are used more advantageously. Also, for components such as HPT blades, the tip areas require oxidation protection whereas the shank areas between an airfoil platform and root serrations often require better high temperature sulfidation (corrosion) resistance. Therefore, in order to tailor the coating requirements for OEM and repair applications, there is a necessity to provide localized or patch coating process capability.

[0008] In the coating industry there are available several localized type aluminiide coating processes. The "codal" coating (General Electric Corp.), “PWA 545” (United Technologies), and “Sermalloy J” (Sermatech International Inc.) are examples for applying a localized diffusion aluminiide coating. Such localized/patch aluminiide coatings have been and are continued to be used in the coating industry. However, the art of applying a localized chromium diffusion coating has not taught the use of an active elements (hafniium, silicon, yttrium, etc.) modified chromium patch process. Therefore, a need exists for developing advanced active elements modified chromium diffusion coatings for improved performance characteristics.

[0009] The patch coating process using a tape or slurry application essentially follows the chemical vapor deposition procedure that occurs in the pack cementation process. Hence, coating formation with simultaneous codeposition of multiple elements can become somewhat complex. Codeposition of dual elements and some processing considerations are described in U.S. Pat. Nos. 5,364,659; 5,589,220; 3,779,719; 5,972,429; and 6,387,194. In addition to providing a general background, the referenced prior art teaching has brought forth the limitations in controlling the thermodynamic activities and vapor pressures for co-deposition of two or more elements in the development of localized patch coating. The situation furthermore becomes increasingly intricate with the need for diffusion of more than two elements for development and formation of active elements modified chromium patch coatings.

[0010] The prior art methods of providing protective coatings have nevertheless experienced additional limitations and drawbacks. One problem that has been encountered is the inability of known methods to apply active elements modified chromium coatings only on selected areas of the target item rather than on the entire surface area of the item.
For example, in turbine blades there is a desire to coat areas “above the platform” that is, the airfoil, with active elements modified chromium (onwards referred to as AEMC) while leaving other areas, the serrations, without a coating. Yet, in other cases, there is a desire to coat areas between serrations and blade platform (also sometimes referred to as the shank portion) with AEMC, while the blade airfoil and platform receive a different functional coating. However, traditional pack cementation methods cannot direct the diffusion to only one area of the turbine blade.

[0011] For instance, it is desired to apply a localized AEMC diffusion coating on an item such as a turbine blade when, for example, the airfoil is receiving other type coatings not intended or otherwise well applied to the shank area. For example, in some applications an MCrAIY type coating is applied to an airfoil and platform region of a turbine blade through an Electron Beam Physical Vapor Deposition (EBPVD) process. Such a process, however, depends for its effectiveness on a line of sight application of the MCrAIY coating. In the shank area of the turbine blade, the process can thus suffer from poor or now coating applicability. Thus some turbine blades receive an MCrAIY coating on the airfoil and do not receive a protective coating on the shank area.

[0012] Further, areas “below the platform” and above the serrations or root of a turbine blade may also be subject to different forms of environmental degradation compared to the airfoil region of the blade. In some instances the shank area of a turbine blade requires primarily sulfidation resistance to Type I and Type II hot corrosion conditions. Chromium and AEMC is an appropriate type coating to protect against this kind of attack. Thus, it would be desired to provide one kind of coating on a turbine blade airfoil (such as high temperature oxidation resistance) while providing an AEMC diffusion coating below the platform. A coating method is therefore needed that can be applied to one area of a turbine blade while not interfering with the coating requirements at a different area of the turbine blade.

[0013] Other instances where a localized diffusion coating would be desired include the seal slot locations in shrouds and ducts as well as seal slots in vane components.

[0014] Hence there is a need for an improved method to apply an active elements modified chromium diffusion protective coating on a metallic item such as a turbine blade. There is a need for an improved coating method that can limit the diffusion of all desired elements to a specific area while avoiding the diffusion in other areas. Moreover there is a need for an improved diffusion method that retains the cost advantages associated with known diffusion methods. The present invention addresses one or more of these needs.

SUMMARY OF THE INVENTION

[0015] The present invention provides a method and materials for applying a diffusion coating on a specific area of a targeted industrial item such as a turbine blade. The method uses a covering material such as a tape, putty, or slurry to cover the area where it is desired that the diffusion occur. The coating material includes metallic sources such as chromium and active elements containing master alloy and/or active elements in metal form for diffusion. The covering material thus defines the localized patch that is to be coated. An activator if any, such as a halide activator, can be included in the tape or slurry. Multiple activators can also be used in the tape/slurry or pack make up. Alternatively, the activator can be included in the pack material. The method uses known pack cementation methods to complete the diffusive process.

[0016] In one embodiment, and by way of example only, there is provided a method for diffusion coating a specific, localized surface of a metallic target comprising the steps of: applying a tape to a surface of a target wherein the tape is impregnated with metal powder comprising chromium and elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium and/or master alloy powder containing active elements; and wherein the tape further comprises a binder material; placing a halide activator (or multiple activators) in proximity to the surface of the target; and heating the target to a temperature sufficient to cause diffusion of the desired metals in the tape into the surface of the target. The step of applying a tape may further include applying a tape wherein the tape is impregnated with a single or multiple halide activators. The step of applying a tape may also include a tape impregnated with metal powder comprising a chromium alloy containing elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium. The tape is shaped to cover a desired area of the target. The tape may also include an inert filler. The step of heating the target may further include heating the tape covered target to a temperature between approximately 1800° F. and 2100° F. and checking the temperature therebetween for between about 2 to about 16 hours. The activators may include encapsulated halide activators as well.

[0017] In a further embodiment, also by way of example only, there is provided a turbine blade ready for diffusion comprising: a turbine blade defining a surface; a tape affixed to a surface of the turbine blade wherein the tape comprises a binder, an inert filler, a halide activator, a chromium containing powder, and a powder of master alloy and/or elements containing metals selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium. The tape may include an adhesive, and the tape may be affixed to the airfoil of the turbine blade.

[0018] In further embodiments the activators, which may include halide activators, are either encapsulated or non-encapsulated, and may be present in either slurries, putties, tapes, and/or in the diffusion packing.

[0019] Other independent features and advantages of the method of patch diffusion coating will become apparent from the following detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is a perspective view of the pack cementation method according to an embodiment of the present invention.

[0021] FIG. 2 is a representative view of a Mar M 247 test bar showing patch chromium diffusion at the bright contrast area where tape was affixed.

[0022] FIG. 3 is a view of patch chromium diffusion on a convex airfoil surface.
FIG. 4 is an SEM micrograph depicting chromium diffusion coating on Mar M 247 test bars.

FIG. 5 is an SEM analyses of chromium diffusion coating with three layers of a T-1555 tape application.

FIG. 6 is an SEM analyses of chromium diffusion coating with one layer of T-1558 tape application.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The following detailed description of the invention is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description of the invention. Reference will now be made in detail to exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

It has now been discovered that a localized active elements modified chromium (AEMC) diffusion coating can be applied to a specific area of an industrial item. In the example of a turbine blade, an AEMC coating can be applied to the shank area below the platform of the blade while the airfoil of the turbine blade does not receive that form of coating. The method takes advantage of tapes, putties, or slurries that can be fabricated to cover or preplace in the desired areas. Chromium, and other desirable metals, are incorporated in the tapes, slurries, or putties. The areas covered by the tape, slurry, or putty, receive the diffusion of the desired metals during the thermal cycles employed for coating formation.

In one preferred embodiment a tape, slurry or putty is prepared using chromium or chromium master alloy powder containing active elements and/or one or more active elements, a carrier, and a binder. Preferably all metal alloy powders used have a mesh size equal to or below 140 mesh. In this embodiment an activator and/or multiple activators, if any, is not included in the slurry, tape, or putty. Rather activators are placed in the pack.

In an alternative embodiment, an activator (or activators) is included in the tape, slurry, or putty. For an AEMC coating, a halide compound is a preferred activator. Activators can be used also in the batch formulations and pack make-ups in combination to accomplish synergetic effects.

The coating tapes that may be used according to one embodiment of the present invention comprise a metal source for all elements (Cr, Hf, Si, Y, etc.), a filler material, a binder material, and optionally, though preferably, an activator material.

The metals in the tape include chromium and at least two or more active elements. The chromium source may be elemental chromium or chromium alloy. Preferably a high purity chromium powder of 99.9% or greater purity is used. Active elements may include silicon, hafnium, yttrium, tantalum, and thorium. Again these elements may be present in elemental form, or in master alloy form.

Some preferred compositions of the active elements containing master alloys area as follows, with weight percentages being nominal.

<table>
<thead>
<tr>
<th>Nominal Composition of Master Alloy</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hf</td>
<td>25%</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
<td>40%</td>
</tr>
<tr>
<td>Ni</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Y</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>5.0%</td>
<td>10%</td>
</tr>
<tr>
<td>Si</td>
<td>bal.</td>
<td>bal.</td>
<td>bal.</td>
<td>bal.</td>
<td>bal.</td>
</tr>
</tbody>
</table>

A further embodiment adds additional materials such as zirconium, rhenium, and tantalum. These elements can be added up to 50% by weight in A, B, C, D, and E master alloy formulations.

It is within the scope of the invention to provide metal powder that is either elemental of each metal or is an alloy of metals. Further the combination of metals in elemental form with metals in alloy form can be adjusted to affect the thermodynamic activity with respect to a given halide activator or activators. Metals in their elemental form tend to have a higher activity for the formation of halide precursors. Elements in the master alloy powders tend to provide a lower activity. Thus, for example if it is desired to increase the diffusion of a given metal, it can be added in elemental form to formulate the pack make-up.

The Argonne National Laboratory Publication ANL-5750 on “The Thermochemical Properties of the Oxides, Fluorides and Chlorides to 2500° K” by Alvin Glassner and the publication “Thermodynamic Properties of Halides” by L. B. Pankratz, United States Department of the Interior, Bureau of Mines, Bulletin 674 provide useful information of relevance to free energy of formation and thermochemical properties of halides, which are of interest in AEMC coating formation. Table I (below) lists estimated free energy of formation values around 1340° K (about 1950°F) coating temperature for some halides of elements of current interest. When dual activators such as chlorides and fluorides are used, it can be noticed from the listed values that the Yttrium and Hafnium chlorides exhibit energy values which are similar in magnitude to those of chromium fluorides. Thus with the aid of pure elements (with unit activities) and master alloy make-ups (with lowered activities of elemental metals) and use of single or multiple activators, that the halides of chromium, hafnium, silicon and yttrium are formed. They generate comparable vapor pressures for co-deposition of these metals on the substrates through the various metal transfer mechanisms.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>ESTIMATED FREE ENERGY OF FORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kcal/gram-atom of halide at 1340° K</td>
</tr>
<tr>
<td>ваться</td>
<td>Estimated Value</td>
</tr>
<tr>
<td>ứớc</td>
<td>(negative quantity)</td>
</tr>
<tr>
<td>SiF₄</td>
<td>82</td>
</tr>
<tr>
<td>HfF₃</td>
<td>86</td>
</tr>
<tr>
<td>HfF₂</td>
<td>90</td>
</tr>
</tbody>
</table>
TABLE I-continued

<table>
<thead>
<tr>
<th>Halide</th>
<th>Estimated Value (negative quantity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HfF₅</td>
<td>92</td>
</tr>
<tr>
<td>YF₅</td>
<td>108</td>
</tr>
<tr>
<td>CrF₅</td>
<td>56</td>
</tr>
<tr>
<td>CrF₇</td>
<td>56</td>
</tr>
<tr>
<td>CrF₈</td>
<td>65</td>
</tr>
<tr>
<td>CrF₉</td>
<td>68</td>
</tr>
<tr>
<td>SiCl₄</td>
<td>26</td>
</tr>
<tr>
<td>HfCl₅</td>
<td>48</td>
</tr>
<tr>
<td>HfCl₆</td>
<td>40</td>
</tr>
<tr>
<td>CrCl₅</td>
<td>52</td>
</tr>
<tr>
<td>CrCl₆</td>
<td>58</td>
</tr>
<tr>
<td>YCl₄</td>
<td>17</td>
</tr>
<tr>
<td>CrCl₃</td>
<td>23</td>
</tr>
<tr>
<td>CrCl₂</td>
<td>20</td>
</tr>
</tbody>
</table>

The binder is selected from those adhesives used in the art for binding braze tapes to metal surfaces. Such binders are commercially available from welding material suppliers such as Wall Colmonoy Corporation and Vitta Corporation. The binders may be glycerol based, petroleum based, and organic polymeric systems such as acrylic based, alginate based, and gelatin based binders. Typically the commercially available binders include directions for combining the binder with a metal powder and other materials to form a slurry or paste.

Preferred activators include halide sources such as sources of fluorine, chlorine, and bromine. Acceptable activators include ammonium chloride, ammonium iodide, ammonium bromide, ammonium fluoride, ammonium bifluoride, elemental iodine, elemental bromine, hydrogen bromide, aluminum chloride, aluminum fluoride, aluminum bromide, and aluminum iodide. Preferred activators include NH₄Cl and NH₄I. Also, it is preferred to use dual activators, that is both a fluorine and a chlorine source within the same tape, putty, and/or inert pack. Concentration of the halide source within pack 12 may be up to 20% by weight, and more preferably is up to 8% by weight. In one preferred embodiment, the halide concentration is between approximately 1% and approximately 3% by weight.

Inert materials include metal oxides such as alumina. Other preferred inert materials include kaolin, MgO, SiO₂, or Cr₂O₃. The inert fillers may be used singly or in combination. Preferably the inert materials have a non-sintered, flowable grain structure so as not to interfere with the gas transport diffusion of the desired metal.

In forming the slurry or putty form of the present invention, the metallic powder materials are combined with a binder. A filler material may also be included. An activator material may also be included. The mixture is formed to a desired viscosity or consistency. The slurry or putty may then be applied to a surface of a target item. The slurry or putty is typically applied to the surface by manual methods using a tool such as a spatula.

In a further embodiment, a tape is prepared using a chromium or chromium alloy powder along with an active elements source master alloy and/or elemental powders. In forming a tape according to an embodiment of the present invention, a slurry or putty as described above is first created. The slurry or putty preferably includes an inert filler material such as alumina. In this embodiment a powder providing all desired metal sources is mixed with a binder. Known mixing and extrusion methods can be used to form tapes of a desired width and thickness. The Turbochrome division of Chromalloy is one source for the manufacture of tapes with a customer-specified composition.

If an activator is included in a tape, it is preferred that the activator powder be in an encapsulated form. An encapsulated activator is an activator, such as a halide compound, with a covering that surrounds the activator. The encapsulation thus acts to protect the halide from the surrounding environment and also minimizes any reactions the halide compounds might otherwise undergo. The encapsulating material, typically an organic polymer, evaporates during heating at which time the halide compound is released to participate in the diffusion process. A practical disadvantage of using the encapsulated form of activator is that it extends the useful shelf life of a tape. Thus tapes can be manufactured at one location and then distributed to repair facilities. The tapes can then be stored at the repair facilities until needed without losing their effectiveness.

The tapes of one embodiment may also include an adhesive material. Preferably the adhesive material is added to a finished tape on an exterior surface of the tape. When a tape includes an adhesive, the adhesive can be used to secure the tape to a surface of a target item. In practice the adhesive vaporizes during heating and is removed; hence it does not significantly interfere with the diffusion process. Acceptable adhesives include pressure sensitive adhesives. Also, as is known in the art, the adhesive layer may be covered with a backing or protective wrap to prevent the tacky adhesive from bonding to surfaces prior to usage.

Optionally, the tapes may include structural or strengthening elements such as a ceramic gauze. Other metal oxides with binder may also provide the structural function of a ceramic gauze. The structural element, if any, allows gases to flow therethrough so as not to interfere with gas phase diffusion.

The slurries, tapes, and putties of the present invention can have varying concentrations of the metallic components within them. In one embodiment, the chromium concentration is between about 10% to about 80%; and the master alloy powder concentration of any one alloy A through E is about 1% to about 20% in weight. In another embodiment the chromium content is between about 10% to about 80%, silicon is between about 0.5% to about 10%; hafnium is between about 0.5 to about 10%; yttrium is between about 0.5% to about 10.0%. In both these embodiments, there may be other elements added between about 1.0% to about 5%, where the other elements include refractory elements such as tantalum, rhenium, zirconium etc. Also to be included are alloys of these metals. These percentages are measured on a weight percentage basis comparing the metal to metal concentrations. As a whole, the total metal component in the slurries, tapes, and putties can be between about 20% to about 90% with a range of 40% to about 90% being preferred.

The mixing steps described above for making tapes, slurries, and putties can take place using various kinds
of equipment. For small batches, the mixing step using equipment such as a blender found in an industrial laboratory is sufficient. For larger batches industrial-sized blenders and rollers may be preferred. U.S. Pat. No. 5,997,604 describes equipment and methods useful for forming tapes and is incorporated herein.

[0046] Having described the invention from a structural and compositional standpoint, a method of using the invention is now described.

[0047] The tapes, slurries, and putties of the present invention are intended for use with known pack cementation methods. Referring now to FIG. 1 there is shown an illustration of pack cementation equipment for use with the present invention. A retort or box 10 provides a closed container in which the target item rests. Box 10 may include a lid or other opening. If desired the lid may be affixed to the box structure as by welding so as to preclude the entrance of oxygen. Target 11 is placed within box 10. Box 10 and lid are composed of materials such nickel-based superalloys or stainless steel metal capable of withstanding and suitable for heating to elevated temperatures under diffusion coating procedures.

[0048] A pack 12 is also placed within box 10 such that pack 12 surrounds target 11. Pack 12 includes inert materials. Additionally, pack 12 may include activator materials.

[0049] The target item that is to be heat treated may receive a surface preparation in order to facilitate the diffusion process. The preparation may include an inspection, degreasing, and blast cleaning. Further the part may be rinsed with an evaporative solvent to remove any remaining contamination residue.

[0050] A prepared slurry, putty, or tape may then be applied to a desired surface of a target item. The slurries and putties can be applied to a desired surface in a layer with a desired thickness. The tape embodiment is itself flexible so as to permit being shaped to cover complex surfaces. Thus turbine blade airfoils and vanes can be covered by bending and flexing a tape to cover a desired surface. If needed, an adhesive layer can be used to secure the tape to a given surface. In practice the tapes, without added adhesive, may display sufficient tackiness that the tapes will stick to a target item for sufficient time to allow the item to be packed in a heating box. Surrounding the target, that has a tape on its surface, with the pack material, then serves to hold the tape, slurry, or putty in place. With respect to turbine blades, it is preferred to place the chromium with active elements tape on the required portion of the turbine blade (such as the airfoil), while leaving the serration portion of the blade free of tape coverage.

[0051] If an activator is included in tape it is not necessary to include activator materials in the packing inside box 10. However, in an alternative embodiment, dual activators are used in which one activator is used in tape and a second activator, either the same or different from the first activator, is included in the pack 12. If no activator is included in tape it is necessary to include an activator in the pack.

[0052] Once the materials for the pack 12 have been selected and assembled, and the target item 11 has been taped in a desired location, the materials may be placed in box 10 and the box sealed. A heat treatment then takes place. The coating development heat treatment includes heating the box and contents at a constant temperature, up to 2100°F for up to 16 hours. A preferred heat treatment is heating at 1800°F to 2000°F for 6 to 16 hours.

[0053] During the heat treatment mass transportation and diffusion processes take place. Metal ions in the patch make-up react with halide ions. These molecules migrate to the surface of the target through gas transport process. At the surface of the metallic target the elements needed to form the active elements modified chromium coating diffuse with the materials in the target substrate. Temperature and time affect the kinetics of this process. It is also preferred to carry out the heat treatment under an inert atmosphere or vacuum. In some embodiments argon or hydrogen can be flowed through the box in order to maintain an inert atmosphere and to assist with mass transport mechanisms.

[0054] In the following experimental work with only chromium containing tape is provided, to illustrate the overall intent of AEMC coatings. The formation of patch coating using the tape application as an exemplary method is shown in FIG. 2. In the illustrated specimen, coating was effected only on the surface area showing bright contrast and the dark contrasting area did not exhibit chromium addition to the surface. The localized patch coating on the Mar M 247 cylindrical sample was accomplished by: applying three layers of 0.05 inch thick tape (designated as T-155B, obtained through Chromalloy Israel Ltd. as encapsulated ammonium fluoride activated tape) over partial length of rod specimen; packing in a retort containing 2% ammonium chloride activator and 98% of 6 mesh aluminum oxide pack; heating the retort in vacuum furnace with a partial pressure of protective argon gas atmosphere; and with a coating thermal cycle of 1975°F temperature for 7.25 hours. The accomplishment of localized coating with tape application is clearly illustrated in FIG. 2.

[0055] Also the formation of localized patch coating on the convex surface of an airfoil is further represented in FIG. 3. With reference to this Figure, the designation T-1553, T-1555 and T-1558 correspond respectively to 30%, 50% and 80% chromium contained one layer application tapes.

[0056] Furthermore, the microstructures presented in FIG. 4 show the attainment of comparably same coating thickness of about 0.5 mils for the two conditions of three layers of 50% Cr and one layer of 80% Cr under the same coating cycle. From the EDX analysis presented in FIGS. 5 and 6, it is apparent that the three layer (50% Cr tape) application resulted in a higher concentration of 17.3% Cr when compared to one layer (80% Cr tape) application which showed about 14% Cr in the patch coating. However, for the same coating cycle the three layer 80% Cr containing tape (T-1558/3 shown in FIG. 2) produced 22.4% Cr in the patch coating. Moreover, it should be apparent to those familiar with the art that increased patch coating thickness of 1 mil or over can be accomplished by increasing the coating temperature from 1975° F to approximately the 2050°F to 2100°F range. Also, the chromium concentration in the patch coating can be increased from 22.4% to approximately 30% by increasing the concentrations of activators. Thus through the utilization of various degrees of metal powder concentrations, different types and concentrations of activators, as well as application of different coating thermal cycles, it is taught per this invention, the development of AEMC coatings.
0057 While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt to a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

We claim:
1. A method for diffusion coating a surface of a metallic target comprising the steps of:
   applying a tape to a surface of a target wherein the tape is impregnated with metal powder comprising chromium and active elements containing master alloy powder with elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium; and wherein the tape further comprises a binder material;
   placing a halide activator in proximity to the surface of the target; and
   heating the target to a temperature sufficient to cause diffusion of the metals from the tape into the surface of the target.
2. The method according to claim 1 wherein the step of applying a tape further comprises applying a tape wherein the tape is impregnated with a halide activator.
3. The method according to claim 1 wherein the step of applying a tape further comprises a tape impregnated with metal powder comprising a chromium alloy and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium.
4. The method according to claim 1 further comprising shaping the tape to cover a desired area of the target.
5. The method according to claim 1 wherein the step of applying a tape further comprises tape comprising inert filler.
6. The method according to claim 1 wherein the step of heating the target further comprises heating the tape covered target to a temperature between approximately 1800°F and 2100°F and holding the temperature therebetween for between about 2 to about 16 hours.
7. The method according to claim 1 wherein the step of placing a halide activator further comprises placing an encapsulated halide activator.
8. A method for diffusion coating a surface of a metallic target comprising the steps of:
   providing a metal powder comprising chromium and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium wherein the metal powder has a mesh size of 140 or smaller;
   mixing the metal powder with a binder material;
   mixing a halide activator with the metal powder and binder material;
   mixing an inert filler with the metal powder, binder material, and halide activator to form a tape;
   covering a desired surface area of the target with the tape;
   heating the tape covered target to a temperature between approximately 1800°F and 2100°F and holding the temperature therebetween for between about 2 to about 16 hours thereby causing diffusion of the metals into the target surface.
9. A method for diffusion coating a surface of a metallic target comprising the steps of:
   providing a metal powder comprising chromium and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium wherein the metal powder has a mesh size of 130 or smaller;
   mixing the metal powder with a binder material;
   mixing an inert filler with the metal powder, and binder material to form a tape;
   covering a desired surface area of the target with the tape;
   placing the tape-covered target in a diffusion box;
   packing a mixture of halide activator and inert material in the diffusion box around the target;
   heating the slurry covered target in the diffusion box to a temperature between approximately 1800°F and 2100°F and holding the temperature therebetween for between about 2 to about 16 hours thereby causing diffusion of the metals into the surface of the target.
10. A method for preparing a slurry for use in diffusion coating a surface of a metallic target comprising the steps of:
   providing a metal powder comprising chromium and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium wherein the metal powder has a mesh size of 140 or smaller;
   mixing the metal powder with a binder material;
   mixing a halide activator with the metal powder and binder material;
   mixing an inert filler with the metal powder, binder material, and halide activator to form a slurry;
   applying the slurry to a surface of a target in a desired thickness.
11. The method according to claim 10 wherein the step of providing a metal powder further comprises a metal powder comprising a chromium alloy and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium.
12. The method according to claim 10 further comprising covering a desired area of the target with the slurry.
13. The method according to claim 10 wherein the step of mixing a halide activator further comprises mixing an encapsulated halide activator.
14. A method for diffusion coating a surface of a metallic target comprising the steps of:
   providing a metal powder comprising chromium and at least two elements selected from the group consisting
of silicon, hafnium, tantalum, rhenium, and yttrium wherein the metal powder has a mesh size of 140 or smaller;
mixing the metal powder with a binder material;
mixing a halide activator with the metal powder and binder material;
mixing an inert filler with the metal powder, binder material, and halide activator to form a slurry;
applying the slurry to a surface of a target in a desired thickness;
covering a desired area of the target with the slurry;
heating the slurry covered target to a temperature between approximately 1800° F. and 2100° F. and holding the temperature therebetween for between about 2 to about 16 hours.

15. The method according to claim 14 wherein the step of providing a metal powder further comprises a metal powder comprising a chromium alloy and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium.

16. The method according to claim 14 wherein the step of mixing a halide activator further comprises mixing an encapsulated halide activator.

17. A method for diffusion coating a surface of a metallic target comprising the steps of:

providing a metal powder comprising chromium and at least two elements selected from the group consisting of silicon, hafnium, tantalum, rhenium, and yttrium wherein the metal powder has a mesh size of 140 or smaller;
mixing the metal powder with a binder material;
mixing an inert filler with the metal powder, and binder material to form a slurry;
applying the slurry to a surface of a target in a desired thickness;
covering a desired area of the target with the slurry;
placing the slurry-covered target in a diffusion box;
packing a mixture of halide activator and inert material in the diffusion box around the target;
heating the slurry covered target in the diffusion box to a temperature between approximately 1800° F. and 2100° F. and holding the temperature therebetween for between about 2 to about 16 hours.

18. A turbine blade ready for diffusion comprising:
a turbine blade defining a surface;
a tape affixed to a surface of said turbine blade wherein said tape comprises a binder, an inert filler, a halide activator, a chromium containing powder, and a powder containing at least two metals selected from the group consisting of: silicon, hafnium, tantalum, rhenium, and yttrium.

19. The turbine blade according to claim 18 wherein said tape further comprises an adhesive.

20. The turbine blade according to claim 18 wherein said tape is affixed to the airfoil of the turbine blade.