(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 039 167 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
30.10.2019 Bulletin 2019/44

(21) Application number: **14755500.7**

(22) Date of filing: **11.08.2014**

(51) Int Cl.:
C23C 4/18 (2006.01) ***C23C 28/00*** (2006.01)
C23C 4/01 (2016.01)

(86) International application number:
PCT/US2014/050497

(87) International publication number:
WO 2015/031034 (05.03.2015 Gazette 2015/09)

(54) THERMAL SPRAY COATING METHOD AND THERMAL SPRAY COATED ARTICLE

THERMISCHES SPRÜHBESCHICHTUNGSVERFAHREN UND THERMISCHER SPRÜHBESCHICHTETER ARTIKEL

PROCÉDÉ DE REVÊTEMENT PAR PULVÉRISATION THERMIQUE ET ARTICLE REVÊTU PAR PULVÉRISATION THERMIQUE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **29.08.2013 US 201314013194**

(43) Date of publication of application:
06.07.2016 Bulletin 2016/27

(73) Proprietor: **General Electric Company**
Schenectady, NY 12345 (US)

(72) Inventor: **SCHAEFFER, Jon Conrad**
Greenville, SC 29615 (US)

(74) Representative: **BRP Renaud & Partner mbB**
Rechtsanwälte Patentanwälte
Steuerberater
Königstraße 28
70173 Stuttgart (DE)

(56) References cited:
EP-A1- 0 253 754 **EP-A1- 2 100 984**
EP-A1- 2 423 346 **US-A- 4 040 159**
US-A1- 2002 106 457 **US-A1- 2002 141 872**
US-A1- 2006 222 773 **US-A1- 2008 298 975**
US-A1- 2010 075 111 **US-A1- 2012 156 054**

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] The present invention is directed to coating methods and coated articles. More particularly, the present invention is directed to thermal spray coating methods and thermal spray coated articles.

BACKGROUND OF THE INVENTION

[0002] Components, such as airfoils, cooling fins, and fingers, in various equipment are often subjected to increasingly high temperatures. These high temperatures can typically require a cooling mechanism to reduce component temperature and prevent damage to the component.

[0003] One known cooling mechanism includes cooling channels positioned near a hot surface, such as a hot gas path, of a component. In one mechanism, the cooling channels can have a cooling medium in them, such as a gas or a liquid. The cooling medium transports heat away from a region of the component to provide cooling.

[0004] In addition to the cooling channels, components are often thermally sprayed with an environmental coating to handle high temperatures. Applying the environmental coating can result in feedstock filling the cooling channels. Filling of the cooling channels can restrict or stop flow of the cooling medium, thereby reducing or eliminating the cooling provided by the cooling mechanism.

[0005] A coating method and coated article that do not suffer from one or more of the above drawbacks would be desirable in the art.

BRIEF DESCRIPTION OF THE INVENTION

[0006] In an exemplary embodiment, a thermal spray coating method includes positioning a covering on a cooling channel of a component, and thermal spraying a feedstock onto the covering. The covering prohibits the feedstock from entering the cooling channel in the component and is not removed from the component.

[0007] In another exemplary embodiment, a thermal spray coating method includes providing a component comprising a substrate material, providing a cooling channel on a surface of the component, positioning a covering on the cooling channel, and thermal spraying a feedstock onto the component and the covering, the feedstock comprising a bond coat material. The covering prohibits the feedstock from entering the cooling channel.

[0008] In another exemplary embodiment, a thermal spray coated article includes a component, a cooling channel on a surface of the component, a covering on the cooling channel, and a thermally sprayed coating on the component.

[0009] Features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention as set out in claims 1 and 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 shows a thermal spray coating method according to an embodiment of the disclosure.

FIG. 2 shows a mesh covering according to an embodiment of the disclosure.

FIG. 3 shows a perspective view of an article coated by a thermal spray coating method according to an embodiment of the disclosure.

FIG. 4 shows a cross-sectional view corresponding to the article of FIG. 3.

[0011] Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Provided are exemplary thermal spray coating methods and thermal spray coated articles. Embodiments of the present disclosure, in comparison to methods not utilizing one or more features disclosed herein, permit an increase in effectiveness of thermal cooling channels, permit an increase in flow of a cooling medium through the thermal cooling channels, permit an increase in efficiency of thermal spraying, permit a decrease in coating thickness over thermal cooling channels, decrease contamination of thermal cooling channels during thermal spraying, or a combination thereof.

[0013] Referring to FIG. 1, in one embodiment, a thermal spray coating method includes positioning a covering 102 on one or more cooling channels 105 in a component 101, and thermal spraying a feedstock 104 onto the component 101 and the covering 102. The covering 102 prohibits the feedstock 104 from entering the cooling channel 105 in the component 101. In one embodiment, the feedstock 104 includes a bond coat material.

[0014] Suitable coverings 102 include, but are not limited to, a mesh, a foil, or a combination thereof. Suitable forms of the covering 102 include, but are not limited to, planar, curved, molded, contoured, complex, a strip, a sheet, or a combination thereof. For example, in one embodiment, the covering 102 is cut into strips and applied over the surface of the component 101, the strips limited to covering the cooling channel 105 (FIG. 1). In another example, the covering 102 is applied over the entire surface of the component 101 (FIG. 4).

[0015] As used herein, the term "mesh" refers to an arrangement formed from a pattern of interwoven fibers 203 (FIG. 2), machined interwoven foil, or a combination thereof. Suitable patterns of interwoven fibers 203 include, but are not limited to, plain weave, twill, plain dutch weave, twill dutch, twill dutch double, stranded, or a combination thereof. As used herein, the term "foil" refers to a deformable sheet made of any suitable material. Suitable foil configurations include those having openings 204. The foil is resilient and is resistant to deformation from a thermal spraying nozzle 103. The mesh is pliable, for example, capable of extending around a radius of about 30 mils (wherein 1 mil equals 0.0254 mm) without structural damage. In one embodiment, the mesh or the foil is selected as the covering 102, and the thermal spraying nozzle 103 is positioned corresponding to the selected material to reduce or eliminate deformation of the covering 102.

[0016] In one embodiment, the covering 102 is formed by, for example, electrical discharge machining (EDM), metal injection molding, thin sheet processing, or a combination thereof. The covering 102 is either pre-formed or post-formed. Pre-formed includes forming the covering 102 prior to positioning the covering 102 on the component 101. Post-formed includes forming the covering 102 in position on the component 101. In one embodiment, the covering 102 is temporarily or permanently secured to the component 101. Suitable techniques for the securing of the covering 102 to the component 101 include, but are not limited to, tack welding, plating, sintering, brazing, or a combination thereof.

[0017] Suitable compositions of the covering 102 include the substrate material, the bond coat material, or a combination thereof. In one embodiment, the substrate material includes, but is not limited to, cobalt, chromium, tungsten, carbon, nickel, iron, silicon, molybdenum, manganese, alloys thereof, nickel-based alloy, a cobalt-based alloy, superalloys, intermetallics (TiAl and/or NiAl), ceramic matrix composites, or a combination thereof. In one embodiment, the bond coat material includes, but is not limited to, $Ba_{1-x}Sr_xAl_2Si_2O_8$ (BSAS), ceramic oxides, $(Yb,Y)_2Si_2O_7$, mullite with BSAS, Silicon and/or Yttrium mono and/or disilicates, or a combination thereof.

[0018] A suitable nickel-based alloy for use as the substrate material includes, by weight, about 14% chromium, about 9.5% cobalt, about 3.8% tungsten, about 1.5% molybdenum, about 4.9% titanium, about 3.0% aluminum, about 0.1% carbon, about 0.01% boron, about 2.8% tantalum, and a balance of nickel and incidental impurities.

[0019] Another suitable nickel-based alloy includes, by weight, about 7.5% cobalt, about 9.75% chromium, about 4.20% aluminum, about 3.5% titanium, about 1.5% molybdenum, about 4.8% tantalum, about 6.0% tungsten, about 0.5% columbium (niobium), about 0.05% carbon, about 0.15% hafnium, about 0.004 percent boron, and the balance nickel and incidental impurities.

[0020] Another suitable nickel-based alloy for use as the substrate material includes, by weight, between about 0.07% and about 0.10% carbon, between about 8.0% and about 8.7% chromium, between about 9.0% and about 10.0% cobalt, between about 0.4% and about 0.6% molybdenum, between about 9.3% and about 9.7% tungsten, between about 2.5% and about 3.3% tantalum, between about 0.6% and about 0.9% titanium, between about 5.25% and about 5.75% aluminum, between about 0.01% and about 0.02% boron, between about 1.3% and about 1.7% hafnium, up to about 0.1% manganese, up to about 0.06% silicon, up to about 0.01% phosphorus, up to about 0.004% sulfur, between about 0.005% and about 0.02% zirconium, up to about 0.1% niobium, up to about 0.1% vanadium, up to about 0.1% copper, up to about 0.2% iron, up to about 0.003% magnesium, up to about 0.002% oxygen, up to about 0.002% nitrogen, balance nickel and incidental impurities.

[0021] Referring to FIG. 2, in one embodiment, the openings 204 in the covering 102 have a first dimension, such as a first width 201, and a second dimension, such as a second width 202. The first width 201 and the second width 202 at least partially define a predetermined area. The predetermined area of the openings 204 in the covering 102 is smaller than minimum dimensions, such as a minimum width of the feedstock 104, such that the feedstock 104 is unable to pass through the openings 204. The feedstock 104 is directed towards and sprayed onto the component 101, through the thermal spraying nozzle 103. The smaller area of the opening 204 in the covering 102 prevents the feedstock 104 from passing through the covering 102. In one embodiment, the pattern of the interwoven fibers 203 in the mesh forms the openings 204 in the covering 102. In another embodiment, the openings 204 in the covering 102 are formed by machining of the covering 102.

[0022] Suitable dimensions of the opening 204 correspond to a particle size of the feedstock 104. According to the invention the dimensions are, less than 50 μm, between for example approximately 3 μm and approximately 50 μm, between approximately 3 μm and approximately 5 μm, or any combination, sub-combination, range, or sub-range thereof.

[0023] Thermal spraying melts the feedstock 104 and forms molten droplets having a predetermined dimension. The molten droplets are accelerated towards and contact the component 101. The molten droplets flatten upon contact with the component 101. Suitable predetermined dimensions of the feedstock 104 include, but are not limited to, between approximately 2 μm and approximately 50 μm, between approximately 5 μm and approximately 45 μm, between approximately 15 μm and approximately 35 μm, between approximately 2 μm and approximately 30 μm, between approximately 2 μm and approximately 10 μm, between approximately 5 μm and approximately 15 μm, between approximately 10 μm and approximately 20 μm, between approximately 20 μm and approximately 30 μm, between approximately 30 μm and approximately 40 μm, between approximately 40 μm and approximately 50 μm, or any combination, sub-combination, range, or sub-range thereof.

[0024] Referring to FIG. 3, the thermal spraying of the feedstock 104 forms a coating 304 over the component 101. In one embodiment, the covering 102 forms a continuous layer 401 (FIG. 4) between the component 101 and the coating 304, as is shown in section A-A of FIG. 4. In one embodiment, the covering 102 forms a discontinuous layer between the component 101 and the coating 304, as is shown in FIG. 1. The covering 102 is melted, decomposed, oxidized, microstructurally modified, by the thermal spraying, maintained intact, or other suitable combinations thereof. The covering 102 remains as a separate layer between the component 101 and the coating 304 in accordance with claim 15.

[0025] The component 101 is any suitable article or portion of an article, for example, an airfoil, a cooling fin, a finger, a hot-gas-path member, or a combination thereof. Hot-gas-path members are gas turbine members exposed to a combustion process and/or to hot gases discharged from a combustion reaction. Suitable hot-gas-path members include, but are not limited to, a combustion liner, an end cap, a fuel nozzle assembly, a crossfire tube, a transition piece, a turbine nozzle, a turbine stationary shroud, a turbine bucket (blade), turbine disks, turbine seals, or a combination thereof. In one embodiment, the component 101 is capable of withstanding harsh conditions, for example, temperatures of between about 1500°F and about 2600°F, between about 1500°F and about 2100°F, between about 2100°F and about 2600°F, between about 1800°F and about 2300°F, between about 2000°F and about 2400°F, or any suitable range, sub-range, combination, or sub-combination thereof, wherein °C=5/9*(°F-32).

[0026] To prevent heat damage to the component 101, in one embodiment, the cooling channel 105 is provided on a surface 107 of the component 101. In a further embodiment, the cooling channel 105 includes a cooling fluid such as, but not limited to, a gas, a liquid, a refrigerant, or a combination thereof. Suitable embodiments of the cooling channel 105 include, but are not limited to, semicircular, rectangular, triangular, linear, curved, complex, intersecting, parallel, or a combination thereof. The covering 102 prohibits the feedstock 104 from entering the cooling channel 105 during thermal spraying, causing the coating 304 to form over the cooling channel 105 and the covering 102. The coating 304 over the cooling channel 105 prohibits the cooling fluid from escaping the cooling channel 105.

[0027] A thickness of the coating 304 over the cooling channels 105 controls a heat transfer rate of the cooling medium. A decrease in the thickness of the coating 304 increases a cooling rate of the cooling channel 105. Suitable thicknesses of the coating 304 include, but are not limited to, between approximately 150 μm and approximately 4,000 μm, between approximately 300 μm and approximately 1,000 μm, between approximately 200 μm and approximately 800 μm, between approximately 150 μm and approximately 250 μm, between approximately 500 μm and approximately 1,500 μm, or any combination, sub-combination, range, or sub-range thereof.

[0028] 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 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.

Claims

1. A thermal spray coating method, comprising:

   positioning a covering on a cooling channel of a component, the covering having a plurality of openings through the covering and the plurality of openings have dimensions less than 50 μm; and
   thermal spraying a feedstock directly onto the covering, the feedstock (104) being unable to pass through the openings (204);
   wherein the covering prohibits the feedstock from entering the cooling channel in the component.

2. The method of claim 1, further comprising applying a coating over the cooling channel, the covering, and a substrate of the component.

3. The method of claim 1, further comprising transporting a cooling medium through the cooling channel.

4. The method of claim 3, wherein the transporting is devoid of leakage through the coating.

5. The method of claim 1, further comprising securing the covering to the component.

6. The method of claim 1, further comprising tack welding the covering to the component.

7. The method of claim 1, further comprising forming the covering from electrical discharge machining.

8. The method of claim 1, further comprising forming the covering from metal injection molding.

9. The method of claim 1, further comprising melting the covering by the thermal spraying.

10. The method of claim 1, wherein the covering is a

mesh.

11. The method of claim 1, wherein the covering is a foil.

12. The method of claim 1, wherein the thermal spraying of the feedstock applies the feedstock to a portion of the component.

13. The method of claim 1, wherein the thermal spraying of the feedstock applies the feedstock only to the covering.

14. A thermal spray coating method as claimed in claim 1, wherein the feedstock comprises a bond coat material.

15. A thermal spray coated article, comprising:

a component;
a cooling channel on a surface of the component;
a covering on the cooling channel, the covering having a plurality of openings through the covering and the plurality of openings have dimensions less than 50 μm; and
the component and the covering having a thermally sprayed feedstock as a coating directly thereon.

Patentansprüche

1. Thermisches Sprühbeschichtungsverfahren, umfassend:

Positionieren einer Abdeckung auf einem Kühlkanal eines Bauteils, wobei die Abdeckung eine Vielzahl von Öffnungen durch die Abdeckung aufweist und die Vielzahl von Öffnungen Abmessungen aufweisen, die kleiner sind als 50 μm; und
thermisches Sprühen eines Einsatzmaterials direkt auf die Abdeckung, wobei das Einsatzmaterial (104) nicht in der Lage ist, durch die Öffnungen (204) hindurchzutreten;
wobei die Abdeckung verhindert, dass das Einsatzmaterial in den Kühlkanal in dem Bauteil eintritt.

2. Verfahren nach Anspruch 1, ferner umfassend Aufbringen einer Beschichtung über dem Kühlkanal, der Abdeckung und einem Substrat des Bauteils.

3. Verfahren nach Anspruch 1, ferner umfassend Transportieren eines Kühlmediums durch den Kühlkanal.

4. Verfahren nach Anspruch 3, wobei das Transportieren ohne Leckage durch die Beschichtung geschieht.

5. Verfahren nach Anspruch 1, ferner umfassend Befestigen der Abdeckung an dem Bauteil.

6. Verfahren nach Anspruch 1, ferner umfassend Heftschweißen der Abdeckung an das Bauteil.

7. Verfahren nach Anspruch 1, ferner umfassend Umformen der Abdeckung durch Funkenerosion.

8. Verfahren nach Anspruch 1, ferner umfassend Umformen der Abdeckung durch Metallspritzgießen.

9. Verfahren nach Anspruch 1, ferner umfassend Schmelzen der Abdeckung durch das thermische Sprühen.

10. Verfahren nach Anspruch 1, wobei die Abdeckung ein Netz ist.

11. Verfahren nach Anspruch 1, wobei die Abdeckung eine Folie ist.

12. Verfahren nach Anspruch 1, wobei das thermische Sprühen des Einsatzmaterials das Einsatzmaterial auf einen Teil des Bauteils aufbringt.

13. Verfahren nach Anspruch 1, wobei das thermische Sprühen des Einsatzmaterials das Einsatzmaterial nur auf die Abdeckung aufbringt.

14. Thermisches Sprühbeschichtungsverfahren nach Anspruch 1, wobei das Einsatzmaterial ein Haftschichtmaterial umfasst.

15. Thermisch sprühbeschichteter Artikel, umfassend:

ein Bauteil;
einen Kühlkanal auf einer Oberfläche des Bauteils;
eine Abdeckung auf dem Kühlkanal, wobei die Abdeckung eine Vielzahl von Öffnungen durch die Abdeckung aufweist und die Vielzahl von Öffnungen Abmessungen aufweisen, die kleiner sind als 50 μm; und
wobei das Bauteil und die Abdeckung als eine Beschichtung direkt darauf ein thermisch gesprühtes Einsatzmaterial aufweisen.

Revendications

1. Procédé de revêtement par pulvérisation thermique, comprenant :

le positionnement d'un élément de couverture

sur un canal de refroidissement d'un composant, l'élément de couverture ayant une pluralité d'ouvertures à travers l'élément de couverture et la pluralité d'ouvertures ayant des dimensions inférieures à 50 μm ; et
la pulvérisation thermique d'une matière première directement sur l'élément de couverture, la matière première (104) étant incapable de passer à travers les ouvertures (204) ;
dans lequel l'élément de couverture empêche la matière première d'entrer dans le canal de refroidissement dans le composant.

2. Procédé selon la revendication 1, comprenant en outre l'application d'un revêtement sur le canal de refroidissement, l'élément de couverture et un substrat du composant.

3. Procédé selon la revendication 1, comprenant en outre le transport d'un milieu de refroidissement à travers le canal de refroidissement.

4. Procédé selon la revendication 3, dans lequel le transport est exempt de fuite à travers le revêtement.

5. Procédé selon la revendication 1, comprenant en outre la fixation de l'élément de couverture au composant.

6. Procédé selon la revendication 1, comprenant en outre le soudage par points de l'élément de couverture au composant.

7. Procédé selon la revendication 1, comprenant en outre la formation de l'élément de couverture à partir d'un usinage par décharge électrique.

8. Procédé selon la revendication 1, comprenant en outre la formation de l'élément de couverture à partir d'un moulage par injection de métal.

9. Procédé selon la revendication 1, comprenant en outre la fusion de l'élément de couverture par pulvérisation thermique.

10. Procédé selon la revendication 1, dans lequel l'élément de couverture est un treillis.

11. Procédé selon la revendication 1, dans lequel l'élément de couverture est une feuille.

12. Procédé selon la revendication 1, dans lequel la pulvérisation thermique de la matière première applique la matière première à une partie du composant.

13. Procédé selon la revendication 1, dans lequel la pulvérisation thermique de la matière première applique la matière première uniquement à l'élément de couverture.

14. Procédé de revêtement par pulvérisation thermique selon la revendication 1, dans lequel la matière première comprend un matériau de revêtement de liaison.

15. Article revêtu par pulvérisation thermique, comprenant :

un composant ;
un canal de refroidissement sur une surface du composant ;
un élément de couverture sur le canal de refroidissement, l'élément de couverture ayant une pluralité d'ouvertures à travers l'élément de couverture et la pluralité d'ouvertures ayant des dimensions inférieures à 50 μm ; et
le composant et l'élément de couverture ayant une matière première pulvérisée thermiquement comme revêtement directement sur ceux-ci.

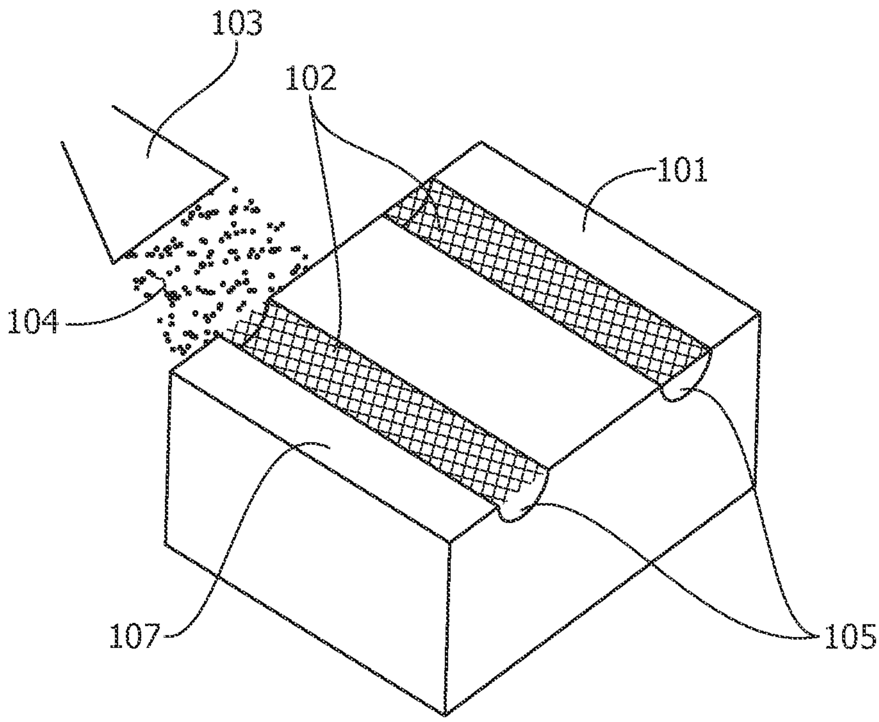

FIG. 1

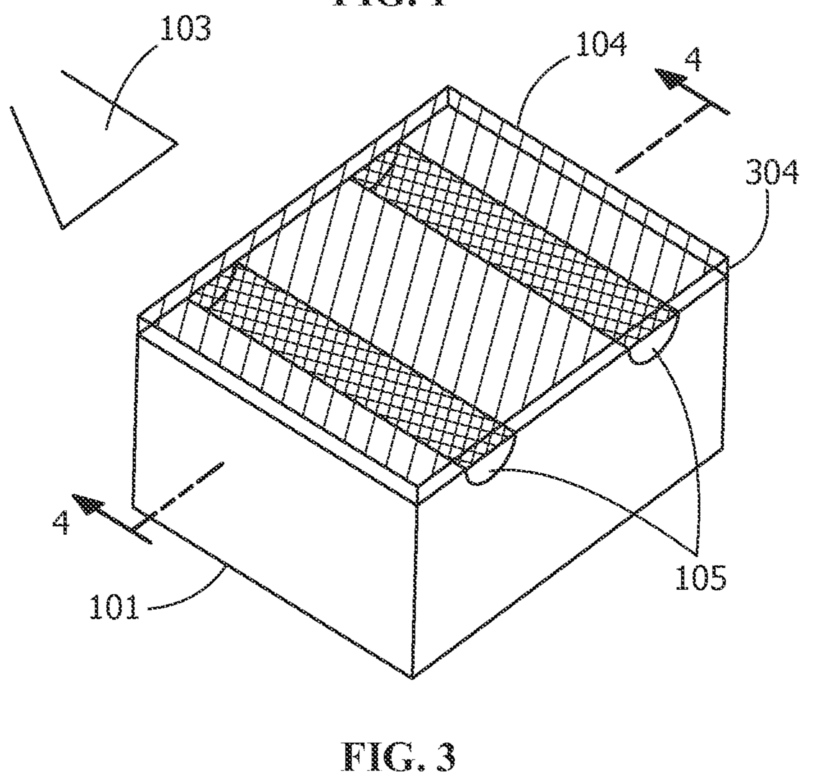

FIG. 3

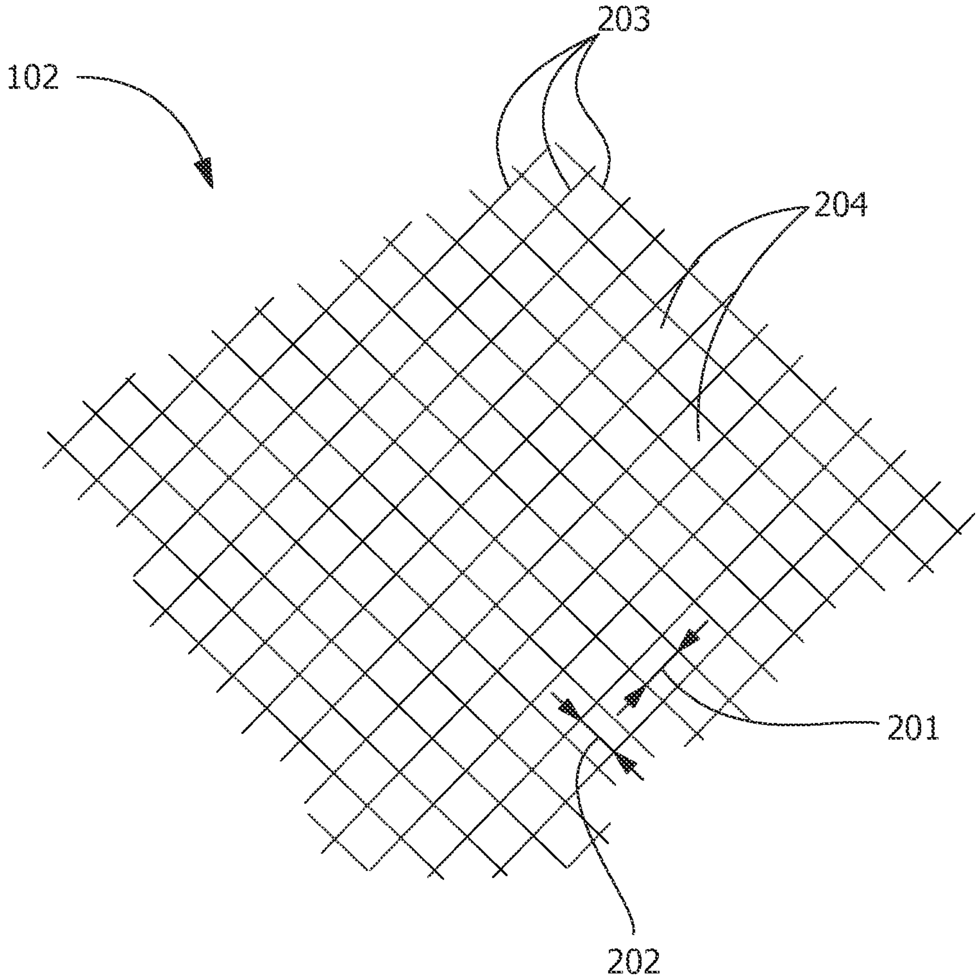

FIG. 2

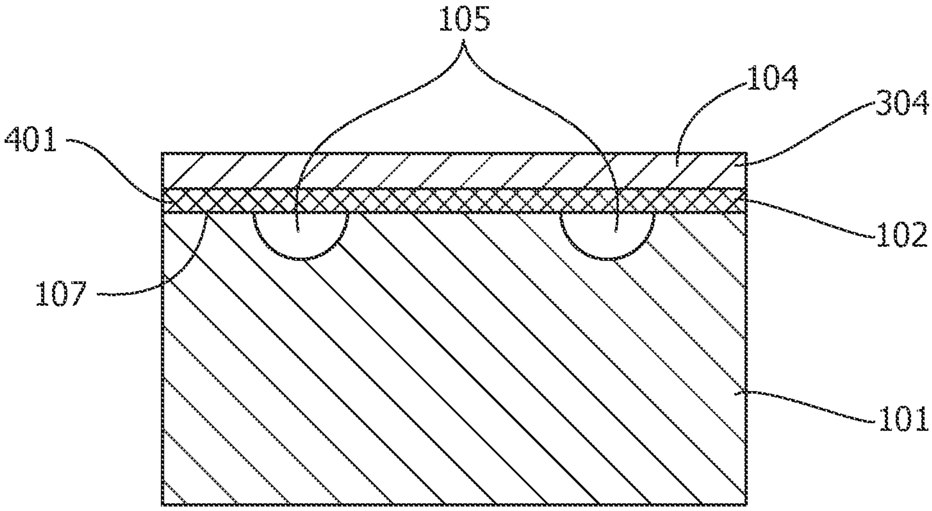

FIG. 4