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(72) Inventor: **FENG, Naixiang**
Shenyang
Liaoning 110004 (CN)

(30) Priority: **08.07.2010 CN 201010220980**

(74) Representative: **Decamps, Alain René François**
Office Kirkpatrick S.A.
Avenue Wolfers, 32
1310 La Hulpe (BE)

(71) Applicant: **Shenyang Beiye Metallurgical Technology Co., Ltd.**
Liaoning 110015 (CN)

(54) **ALUMINUM ELECTROLYTIC CELL HAVING CATHODE CARBON BLOCK WITH COLUMNAR PROTRUSIONS EMBEDDED ON ITS UPPER SURFACE**

(57) An aluminum electrolytic cell having cathode carbon block with columnar protrusions (4) embedded on its upper surface is disclosed. The columnar protrusions (4) are arranged into two rows or three rows in the length direction of the upper surface of the carbon block. Two adjacent rows of columnar protrusions (4) are criss-cross arranged, and the columnar protrusions (4) of the

cathode carbon block (10) are immersed in the aluminum liquid. The pot holes in the positions of the cathode carbon block substrate (3) and the upper surface of the cathode carbon block substrate (3) where columnar protrusions (4) are embedded can be one-step molded by vibration molding or compression molding, and can be made by machining as well.

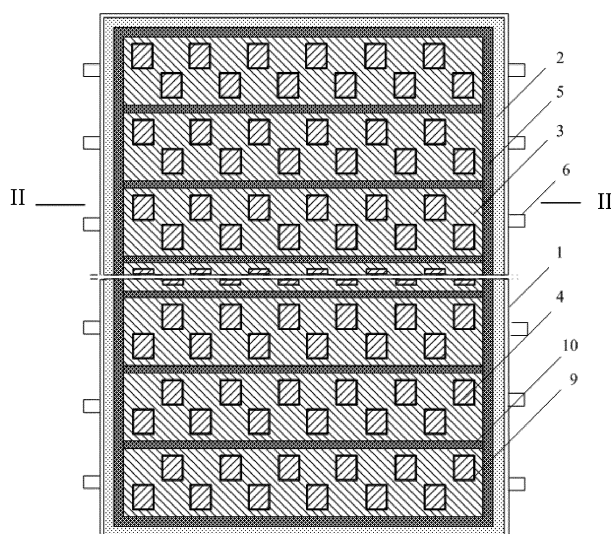


Figure 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to the technical field of aluminum electrolytic cell, in particular to an aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface.

2. The Prior Arts

[0002] At present, industrial pure aluminum is prepared by using an electrolysis method for molten cryolite alumina salts, and an anode of an electrolytic cell is composed of anode carbon blocks prepared from calcined petroleum coke. A cathode of the electrolytic cell is also composed of carbon blocks. The bottom of each cathode carbon block is provided with a steel bar, both ends of the steel bar are extended from the two sides of the electrolytic cell and are connected with a cathode bus, and one cathode carbon block is bonded to the other cathode carbon block by carbon paste.

[0003] At present, most cathode carbon blocks of industrial aluminum electrolytic cells are made of anthracite which is calcined at high temperature. To increase the conductivity and the corrosion resistance to sodium and electrolyte of the cathode carbon blocks, artificial graphite is added into the ingredients of electrically-calcined anthracite carbon blocks which are widely used. When the content of the artificial graphite generally accounts for 30-50% of the aggregate ingredient of the whole cathode carbon block, the cathode carbon block is called half-graphite cathode carbon block. Full-graphite carbon block is also used. The so-called full-graphite cathode carbon block is a carbon block when all the aggregate ingredients (including powder material) used for making the cathode carbon block are artificial graphite (100%). In addition, to enable the cathode carbon block to have lower resistance and better corrosion resistance to sodium and electrolyte in order that the cathode of the electrolytic cell can have smaller cathode voltage drop and longer service life, many electrolytic cells with large capacity begin to use graphitized cathode carbon blocks or semi-graphitized cathode carbon blocks which are fully made of petroleum coke. However, after the half-graphite, graphite and graphitized cathode carbon blocks are used as the cathode carbon blocks of the aluminum electrolytic cells, with the increase of the constituent content of artificial graphite in the cathode carbon blocks, the strength and erosion and corrosion resistance of the cathode carbon blocks to the aluminum liquid in the electrolytic cell become poorer and poorer.

[0004] In 2007, Feng Naixiang, from Northeastern University, invented an aluminum electrolytic cell with irregular cathode structure, and the aluminum electrolytic cell with irregular cathode structure is characterized in that

the surface of the cathode carbon block is provided with protrusions. The protrusions have the functions for greatly reducing the flow speed and fluctuation of the aluminum liquid and increasing the stability of the aluminum liquid in the electrolytic cell. Thus, the cell voltage of the electrolytic cell is greatly reduced, the current efficiency is further increased, and the effect of greatly reducing the electric power consumption of the aluminum electrolytic cell is obtained.

[0005] One crucial technical requirement to the cathode of the aluminum electrolytic cell with irregular cathode structure is that: the protrusions on the cathode carbon block of the electrolytic cell must have better erosion resistance to the cathode aluminum liquid. The traditional cathode carbon block mainly made of calcined anthracite has high erosion resistance to the cathode aluminum liquid. The practice of the series production of aluminum electrolytic cell with irregular cathode structure indicates that for the anthracite carbon block which has protrusions on its cathode surface and includes 30% artificial graphite, the consumption of the protrusions on the cathode surface of the carbon block can be reduced to 10 mm/year, and the height of the cathode protrusions can be 110 mm. Therefore, the cathode carbon block which is made of anthracite used as main aggregate material and is provided with protrusions on the surface of the cathode carbon block can meet the requirement of the aluminum electrolytic cell to the life of the protrusions of the cathode carbon block.

[0006] However, for the graphite cathode carbon block or graphitized cathode carbon block which is mainly made of artificial graphite used as main aggregate material, the erosion resistance of the cathode carbon block to the aluminum liquid is far less than that of the cathode carbon block mainly made of anthracite used as main aggregate material, and the erosion resistance of the latter is several times as many as that of the former. Therefore, the graphite or graphitized cathode carbon block which is provided with protrusions on its surface cannot well meet the requirement of the aluminum electrolytic cell with irregular cathode structure to the life of the protrusions on its cathode surface. In addition, the cathode carbon block of the aluminum electrolytic cell whose surface has horizontal protrusions perpendicular to the vertical direction of the cathode carbon block of the electrolytic cell has the disadvantages of large processing amount and high material consumption, thereby increasing the material cost, the processing cost and the production cost.

SUMMARY OF THE INVENTION

[0007] In terms of the above problems, the present invention provides an aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface. By embedding protrusions on the surface of the anthracite carbon block or the upper surface of the full-graphite or semi-graphitized or fully-

graphitized cathode carbon block substrate, the cathode carbon block has high erosion resistance to the aluminum liquid.

[0008] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of the present invention comprises a cell shell, a cell lining refractory insulation material, side carbon bricks, cathode carbon blocks and cathode steel bars. Carbon paste is filled between two cathode carbon blocks, and each cathode carbon block is rammed with each side carbon brick by the carbon paste; wherein the cathode carbon block consists of a cathode carbon block substrate and columnar protrusions on the upper surface of the substrate, and the columnar protrusions are embedded on the upper surface of the cathode carbon block substrate.

[0009] Graphite paste is filled between the columnar protrusions and the cathode carbon block substrate, and the graphite paste is prepared by mixing thermosetting resin and graphite powder.

[0010] The cathode carbon block substrate is cuboid, the upper surface of the cathode carbon block substrate is provided grooves, and the columnar protrusions are embedded on the upper surface of the cathode carbon block substrate by the grooves.

[0011] The columnar protrusions are cuboid or cylindrical.

[0012] The columnar protrusions are made of calcined anthracite, or the mixture of calcined anthracite and artificial graphite, or artificial graphite broken into aggregate and asphalt which are kneaded and then roasted, or made of artificial graphite electrode and graphite block by processing. When the columnar protrusions are cylindrical, a part of the side surface of the columnar protrusions embedded into the cathode carbon block substrate is machined with external threads.

[0013] In the above electrolytic cell, when the columnar protrusions are cuboid, the length direction of the columnar protrusions is perpendicular to that of the cathode carbon block substrate. Under the condition that the width of the cathode carbon block substrate is 50-70 cm, the length of the columnar protrusions is 21-35 cm, the width of the columnar protrusions is 17-30 cm, and the height difference between the columnar protrusions and the cathode carbon block substrate is 9-15 cm. When the width of the cathode carbon block substrate is increased, the length of the columnar protrusions is increased in accordance with the increased proportion of the width of the cathode carbon block substrate.

[0014] In the above electrolytic cell, when the columnar protrusions are cylindrical, and the width of the cathode carbon block substrate is 50-70 cm, the diameter of the columnar protrusions is 17-35 cm, and the height difference between the columnar protrusions and the cathode carbon block substrate is 9-15 cm. When the width of the cathode carbon block is increased, the diameter of the columnar protrusions is increased in accordance with the increased proportion of the width of the cathode carbon

block substrate.

[0015] In the above electrolytic cell, the columnar protrusions are arranged into two rows or three rows in the length direction of the upper surface of the cathode carbon block substrate, and two adjacent rows of columnar protrusions are crisscross arranged. Under the condition that the width of the cathode carbon block substrate is 50-70 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 17-35 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 5-20 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 30-70 cm.

[0016] The depth of the above columnar protrusions in the cathode carbon block substrate is 5-10 cm.

[0017] The cathode carbon block of the aluminum electrolytic cell of the present invention is prepared in accordance with the following steps:

[0018] 1. The method for preparing the cathode carbon block substrate is divided into two types:

[0019] (1) Machining: circular pot holes of 5-10 cm in depth are machined in the positions where columnar protrusions are embedded of the upper surface of the anthracite or graphite cathode carbon block substrate prepared at 1100°C-1300°C or the upper surface of the semi-graphitized or graphitized cathode carbon block substrate which is graphitized at 2300°C-2500°C after being roasted at 1100°C-1300°C, the side wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions;

[0020] (2) Vibration molding or compression molding: when using vibration molding or compression molding to prepare the green compact of cathode carbon block substrate, the bottom surface of a heavy object on the material in the vibration molding mold is changed from a traditional plane into a structure with protrusions, or the bottom surface of a compression mold on the material in the mold is changed from a traditional plane into a structure having protrusions on its surface during compression molding; thus, after the cathode carbon block substrate is prepared by vibration molding or compression molding, the upper surface of the green compact of the cathode carbon block substrate which is prepared by vibration molding or compression molding has pot holes used for arranging the columnar protrusions; wherein the distribution locations of the protrusions on the bottom surface of the heavy object on the material in the mold or the mold bottom surface of the material in the mold correspond to the locations of the columnar protrusions embedded on the upper surface of the cathode carbon block substrate; the shape of the protrusions is consistent with that of the pot holes for arranging the columnar protrusions embedded on the upper surface produced by vibration molding or compression molding; the depth of the pot holes is 5-10 cm; when the cathode carbon block substrate is an anthracite cathode carbon block sub-

strate, a graphite cathode carbon block substrate or a semi-graphite cathode carbon block substrate, the green compact of the above cathode carbon block is roasted at 1100°C-1300°C to be prepared into a cathode carbon block substrate with pot holes; when the cathode carbon block substrate is a graphitized or a semi-graphitized cathode carbon block substrate, the roasting method and the method for making the pot holes are the same as those used in method (1), the cathode carbon block substrate is treated at high temperature of 2300°C-3000°C in a graphitizing furnace after being roasted to be prepared into a semi-graphitized or a fully-graphitized cathode carbon block substrate; the pot holes on the upper surface of the cathode carbon block substrate are divided into circular pot holes and square pot holes; when the pot holes are circular pot holes, the inner wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions; when the pot holes are square pot holes, the inner wall of each pot hole is provided with at least four circular pits with the diameter of not less than 5 mm and depth of not less than 10 mm;

[0021] 2. Thermosetting resin is mixed with graphite powder to prepare graphite paste, and the mix proportion is required to be capable of mixing paste; the graphite paste is filled into the pot holes; the columnar protrusions are arranged into the pot holes, wherein when the columnar protrusions are cuboid, the pot holes are square pot holes, the length and the width of the pot holes are 1-10 mm more than the length and the width of the columnar protrusions, and the cuboid columnar protrusions are vertically compressed into the pot holes; when the columnar protrusions are cylindrical, the pot holes are circular, and the side wall is machined with internal threads; the external threads of the columnar protrusions are matched with the internal threads of the pot holes, the columnar protrusions are screwed in the pot holes, and graphite paste is filled in the gap between the internal threads and the external threads; after the columnar protrusions are arranged into the pot holes, a part of the graphite paste in the pot holes is extruded from the gap between the protrusions and the pot holes, and then is accumulated at the junction of the upper surface of the cathode carbon block substrate and the columnar protrusions.

[0022] In the process of roasting the aluminum electrolytic cell, the volatile matter is discharged from the thermosetting resin of the graphite paste to be carbonized, and then the columnar protrusions are more closely connected with the cathode carbon block substrate.

[0023] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is electrolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10

cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

[0024] In the present invention, by embedding columnar protrusions on the cathode carbon block substrate, it is allowable to reduce the filtrate fluctuation ability and have multiple choices for substrate materials of the cathode carbon block, thereby achieving the effect of improving the working ability of the cathode carbon block and increasing the life of the cathode carbon block. Meanwhile, the method of embedding columnar protrusions on the cathode carbon block substrate has the advantages of less processing amount and lower cost as compared with the original method of directly preparing protrusions on the cathode carbon block. Test indicates that the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of the present invention has stable working performance and is capable of effectively reducing the flow speed and fluctuation of the aluminum liquid to enable the cell to be normally operated at lower cell voltage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Figure 1 is a top view of the aluminum electrolytic cell of the first example of the present invention.

[0026] Figure 2 is a sectional view taken along line II-II in Figure 1.

[0027] Figure 3 is a top view of the aluminum electrolytic cell of the second example of the present invention.

[0028] Figure 4 is a sectional view taken along line IV-IV in Figure 3.

[0029] Figure 5 is a top view of the aluminum electrolytic cell of the third example of the present invention.

[0030] Figure 6 is a sectional view taken along line VI-VI in Figure 5.

[0031] Figure 7 is a top view of the aluminum electrolytic cell of the fourth example of the present invention.

[0032] Figure 8 is the sectional view taken along line VIII-VIII in Figure 7.

[0033] Figure 9 is a top view of the aluminum electrolytic cell of the fifth example of the present invention; and

[0034] Figure 10 is a sectional view taken along line X-X in Figure 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0035] The width of the cathode carbon block substrate in the example of the present invention is 50-70 cm.

[0036] The graphite paste in the example of the present invention is prepared by mixing thermosetting resin and graphite powder, and the mix proportion is required to be capable of mixing paste.

[0037] The preparation method of the cathode carbon block in the example of the present invention is as follows:

[0038] 1. The method for preparing the cathode carbon block substrate is divided into two types:

[0039] (1) Machining: circular pot holes of 5-10 cm in

depth are machined in the positions where columnar protrusions are embedded of the upper surface of the anthracite or graphite cathode carbon block substrate prepared at 1100°C-1300°C or the upper surface of the semi-graphitized or graphitized cathode carbon block substrate which is graphitized at 2300°C-2500°C after being roasted at 1100°C-1300°C, the side wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions;

[0040] (2) Vibration molding or compression molding: when using vibration molding or compression molding to prepare the green compact of cathode carbon block substrate, the bottom surface of a heavy object on the material in the vibration molding mold is changed from a traditional plane into a structure with protrusions, or the bottom surface of a compression mold on the material in the mold is changed from a traditional plane into a structure having protrusions on its surface during compression molding; thus, after the cathode carbon block substrate is prepared by vibration molding or compression molding, the upper surface of the green compact of the cathode carbon block substrate which is prepared by vibration molding or compression molding has pot holes used for arranging the columnar protrusions; wherein the distribution locations of the protrusions on the bottom surface of the heavy object on the material in the mold or the mold bottom surface of the material in the mold correspond to the locations of the columnar protrusions embedded on the upper surface of the cathode carbon block substrate; the shape of the protrusions is consistent with that of the pot holes for arranging the columnar protrusions embedded on the upper surface produced by vibration molding or compression molding; the depth of the pot holes is 5-10 cm; when the cathode carbon block substrate is an anthracite cathode carbon block substrate, a graphite cathode carbon block substrate or a semi-graphite cathode carbon block substrate, the green compact of the above cathode carbon block is roasted at 1100°C-1300°C to be prepared into a cathode carbon block substrate with pot holes; when the cathode carbon block substrate is a graphitized or a semi-graphitized cathode carbon block substrate, the roasting method and the method for making the pot holes are the same as those used in method (1), the cathode carbon block substrate is treated at high temperature of 2300°C-3000°C in a graphitizing furnace after being roasted to be prepared into a semi-graphitized or a fully-graphitized cathode carbon block substrate; the pot holes on the upper surface of the cathode carbon block substrate are divided into circular pot holes and square pot holes; when the pot holes are circular pot holes, the inner wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions; when the pot holes are square pot holes, the inner wall of each pot hole is provided with at least four circular pits with the diameter of not less than 5 mm and depth of not less than 10 mm;

[0041] 2. Thermosetting resin is mixed with graphite powder to prepare graphite paste, and the mix proportion is required to be capable of mixing paste; the graphite paste is filled into the pot holes; the columnar protrusions are arranged into the pot holes, wherein when the columnar protrusions are cuboid, the pot holes are square pot holes, the length and the width of the pot holes are 1-10 mm more than the length and the width of the columnar protrusions, and the cuboid columnar protrusions are vertically compressed into the pot holes; when the columnar protrusions are cylindrical, the pot holes are circular, and the side wall is machined with internal threads; the external threads of the columnar protrusions are matched with the internal threads of the pot holes, the columnar protrusions are screwed in the pot holes, and graphite paste is filled in the gap between the internal threads and the external threads; after the columnar protrusions are arranged into the pot holes, a part of the graphite paste in the pot holes is extruded from the gap between the protrusions and the pot holes, and then is accumulated at the junction of the upper surface of the cathode carbon block substrate and the columnar protrusions.

Example 1

[0042] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is shown in Figure 1, and the sectional view taken along line II-II in Figure 1 is shown in Figure 2. The electrolytic cell comprises a cell shell 1, a cell lining refractory insulation material, side carbon bricks 2, cathode carbon blocks and cathode steel bars 6. Carbon ramming paste between cathode carbon blocks 10 is filled between two cathode carbon blocks, and each cathode carbon block is rammed with each side carbon brick by the carbon paste 5; wherein the cathode carbon block consists of a cathode carbon block substrate 3 and columnar protrusions 4 on the upper surface of the cathode carbon block substrate 3, and the columnar protrusions 4 are embedded on the upper surface of the cathode carbon block substrate 1. The cell lining refractory insulation material comprises a cell bottom refractory insulation material 7 and a cell side refractory insulation material 8, and the side carbon paste 5 is arranged in the side carbon bricks 2.

[0043] The cathode carbon block substrate 3 is cuboid, the upper surface of the cathode carbon block substrate 3 has grooves, and the columnar protrusions 4 are embedded on the upper surface of the cathode carbon block substrate 3. The columnar protrusions 4 are cuboid, and the graphite paste 9 is filled between the columnar protrusions 4 and the cathode carbon block substrate 3.

[0044] The length direction of the columnar protrusions is perpendicular to that of the cathode carbon block substrate, the length of the columnar protrusions is 30 cm, the width of the columnar protrusions is 20 cm, and the height difference between the columnar protrusions and

the upper surface of the cathode carbon block substrate is 9 cm.

[0045] The columnar protrusions are arranged into two rows in the length direction of the upper surface of the cathode carbon block substrate, all the columnar protrusions are uniformly distributed on the upper surface of the cathode carbon block substrate, and two adjacent rows of columnar protrusions are crisscross arranged. The distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 17-35 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 20 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 60 cm.

[0046] The above columnar protrusions are made of calcined anthracite which is molded and roasted.

[0047] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is electrolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10 cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

Example 2

[0048] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is shown in Figure 3, and the sectional view taken along line IV-IV in Figure 3 is shown in Figure 4. The structure of the electrolytic cell is consistent with that of the electrolytic cell in example 1, and is differentiated from that of the electrolytic cell in example 1 in that:

[0049] The columnar protrusions are arranged in three rows in the length direction of the upper surface of the cathode carbon block substrate, the length of the columnar protrusions is 21 cm, the width of the columnar protrusions is 19 cm, and the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 10 cm. The distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 25 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 5 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 50 cm.

[0050] The columnar protrusions are made of the mixture of calcined anthracite and artificial graphite.

[0051] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is elec-

trolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10 cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

Example 3

[0052] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is shown in Figure 5, and the sectional view taken along line VI-VI in Figure 5 is shown in Figure 6. The structure of the electrolytic cell is consistent with that of the electrolytic cell in example 1, and is differentiated from that of the electrolytic cell in example 1 in that:

[0053] Under the condition that the columnar protrusions are cylindrical and the width of the cathode carbon block substrate is 50-70 cm, the diameter of the columnar protrusions is 25 cm, the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 11 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 30 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 20 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 40 cm.

[0054] The columnar protrusions are made of artificial graphite which is moulded and roasted.

[0055] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is electrolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10 cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

Example 4

[0056] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is shown in Figure 7, and the sectional view taken along line VIII-VIII in Figure 7 is shown in Figure 8. The structure of the electrolytic cell is consistent with that of the electrolytic cell in example 3, and is differentiated from that of the electrolytic cell in example 3 in that:

[0057] The columnar protrusions are arranged in three rows in the length direction of the upper surface of the cathode carbon block substrate, the diameter of the columnar protrusions is 17 cm, the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 11 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 19 cm, the distance between two adjacent columnar protrusions of the

columnar protrusions of different rows on the same cathode carbon block is 5 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 30 cm.

[0058] The columnar protrusions are made of artificial graphite electrode and graphite block by processing.

[0059] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is electrolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10 cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

Example 5

[0060] The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is shown in Figure 9, and the sectional view taken along line X-X in Figure 9 is shown in Figure 10. The structure of the electrolytic cell is consistent with that of the electrolytic cell in example 1, and is differentiated from that of the electrolytic cell in example 1 in that:

[0061] Under the condition that the width of the cathode carbon block substrate is 66 cm, the length of the columnar protrusions is 30 cm, the width of the columnar protrusions is 23 cm, and the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 11 cm. The distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 35 cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 10 cm, and the distance between two columnar protrusions adjacent to the aluminum outlet is 70 cm.

[0062] The working condition when aluminum electrolysis is performed in the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface is that: all the columnar protrusions of the cathode carbon block should be immersed in the aluminum liquid, the upper aluminum liquid is electrolyte melt, the height of the aluminum liquid level is higher than the upper surface of the protrusions and is 1-10 cm after aluminum production, and the working voltage of the electrolytic cell is 3.5-3.9 V

PARTS LIST

[0063]

- | | |
|---|--------------------------------|
| 1 | cell shell |
| 2 | side carbon brick |
| 3 | cathode carbon block substrate |
| 4 | columnar protrusion |

(continued)

- | | |
|----|--------------------------------|
| 5 | side carbon paste |
| 6 | cathode steel bar |
| 7 | refractory insulation material |
| 8 | refractory insulation material |
| 9 | graphite paste |
| 10 | carbon ramming paste |

Claims

1. An aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface, comprising: cathode carbon blocks, wherein each cathode carbon block is composed of a cathode carbon block substrate and a plurality of columnar protrusions embedded on the upper surface of the cathode carbon block substrate.
2. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein thermosetting resin is mixed with graphite powder to prepare graphite paste, and the graphite paste is filled between the columnar protrusions and the cathode carbon block substrate.
3. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the cathode carbon block substrate is cuboid, the upper surface of the cathode carbon block substrate is provided with grooves, and the columnar protrusions are embedded on the upper surface of the cathode carbon block substrate by the grooves.
4. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the columnar protrusions are cuboid or cylindrical.
5. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the columnar protrusions are made of calcined anthracite, or the mixture of calcined anthracite and artificial graphite, or artificial graphite broken into aggregate and asphalt which are kneaded and then roasted, or made of artificial graphite electrode and graphite block by processing.
6. A preparation method of the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the method comprises the following steps:

(1) Using two methods to prepare the cathode carbon block substrate:

1) Extrusion method: when the cross section of the cathode carbon block substrate is a regular rectangular cross section, green compact of cathode carbon block substrate is prepared, the prepared green compact is prepared into anthracite or graphite cathode carbon block substrate after being roasted at 1100°C-1300°C or prepared into semi-graphitized cathode carbon block substrate after being roasted at 1100°C-1300°C or being heat-treated at 2300°C-2500°C, circular pot holes of 5-10cm in depth are machined in the positions where columnar protrusions are embedded of the upper surface of the cathode carbon block substrate, the side wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions;

2) Vibration molding or compression molding: when using vibration molding or compression molding to prepare the green compact of cathode carbon block substrate, the bottom surface of a heavy object on the material in the vibration molding mold is changed from a traditional plane into a structure with protrusions, or the bottom surface of a compression mold on the material in the mold is changed from a traditional plane into a structure having protrusions on its surface during compression molding; thus, after the cathode carbon block substrate is prepared by vibration molding or compression molding, the upper surface of the green compact of the cathode carbon block substrate which is prepared by vibration molding or compression molding has pot holes used for arranging the columnar protrusions; wherein the distribution locations of the protrusions on the bottom surface of the heavy object on the material in the mold or the mold bottom surface of the material in the mold correspond to the locations of the columnar protrusions to be embedded on the upper surface of the cathode carbon block substrate; the shape of the protrusions is consistent with that of the pot holes for arranging the columnar protrusions embedded on the upper surface produced by vibration molding or compression molding; the depth of the pot holes is 5-10cm; when the cathode carbon block substrate is an anthracite cathode carbon block substrate, a graphite cathode carbon block substrate or a semi-graphite cathode

carbon block substrate, the green compact of the above cathode carbon block is roasted at 1100°C-1300°C to be prepared into a cathode carbon block substrate with pot holes; when the cathode carbon block substrate is a graphitized or a semi-graphitized cathode carbon block substrate, the roasting method and the method for making the pot holes are the same as those used in method 1), the cathode carbon block substrate is heat-treated at 2300°C-3000°C in a graphitizing furnace after being roasted to be prepared into a semi-graphitized or a fully-graphitized cathode carbon block substrate; the pot holes in the upper surface of the cathode carbon block substrate are divided into circular pot holes and square pot holes; when the pot holes are circular pot holes, the inner wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions; when the pot holes are square pot holes, the inner wall of each pot hole is provided with at least four circular pits with the diameter of not less than 5mm and depth of not less than 10mm;

(1) (2) Embedding columnar protrusions: thermosetting resin is mixed with graphite powder to prepare graphite paste, and the mix proportion is required to be capable of mixing paste; the graphite paste is filled into the pot holes; the columnar protrusions are arranged into the pot holes, wherein when the columnar protrusions are cuboid, the pot holes are square pot holes, the length and the width of the pot holes are 1-10mm more than the length and the width of the columnar protrusions, and the cuboid columnar protrusions are vertically compressed into the pot holes; when the columnar protrusions are cylindrical, the pot holes are circular, and the side wall of each pot hole is machined with internal threads; the external threads of the columnar protrusions are matched with the internal threads of the pot holes, the columnar protrusions are screwed in the pot holes, and graphite paste is filled in the gap between the internal threads and the external threads; after the columnar protrusions are arranged into the pot holes, a part of the graphite paste in the pot holes is extruded out from the gap between the protrusions and the pot holes, and then is accumulated at the junction of the upper surface of the cathode carbon block substrate and the columnar protrusions.

Amended claims under Art. 19.1 PCT

1. An aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface, comprising: cathode carbon blocks, wherein each cathode carbon block is composed of a cathode carbon block substrate and a plurality of columnar protrusions embedded on the upper surface of the cathode carbon block substrate, the cathode carbon block substrate is cuboid, the upper surface of the cathode carbon block substrate is provided grooves, and the columnar protrusions are embedded on the upper surface of the cathode carbon block substrate by the grooves; the columnar protrusions are cuboid or cylindrical; when the columnar protrusions are cuboid, the length direction of the columnar protrusions is perpendicular to that of the cathode carbon block substrate, under the condition that the width of the cathode carbon block substrate is 50-70cm, the length of the columnar protrusions is 21-35cm, the width of the columnar protrusions is 17-30cm, and the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 9-15cm; when the width of the cathode carbon block substrate is increased, the length of the columnar protrusions is increased in accordance with the increased proportion of the width of the cathode carbon block substrate; when the columnar protrusions are cylindrical, and the width of the cathode carbon block substrate is 50-70cm, the diameter of the columnar protrusions is 17-35cm, and the height difference between the columnar protrusions and the upper surface of the cathode carbon block substrate is 9-15cm; when the width of the cathode carbon block is increased, the diameter of the columnar protrusions is increased in accordance with the increased proportion of the width of the cathode carbon block substrate; the columnar protrusions are arranged into two rows or three rows in the length direction of the upper surface of the cathode carbon block substrate, and two adjacent rows of columnar protrusions are crisscross arranged; under the condition that the width of the cathode carbon block substrate is 50-70cm, the distance between two adjacent columnar protrusions of the columnar protrusions of the same row is 17-35cm, the distance between two adjacent columnar protrusions of the columnar protrusions of different rows on the same cathode carbon block is 5-20cm, the distance between two columnar protrusions adjacent to the aluminum outlet is 30-70cm, and the depth of the above columnar protrusions in the cathode carbon block substrate is 5-10cm.

2. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein thermosetting

resin is mixed with graphite powder to prepare graphite paste, and the graphite paste is filled between the columnar protrusions and the cathode carbon block substrate.

3. The aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the columnar protrusions are made of calcined anthracite, or the mixture of calcined anthracite and artificial graphite, or artificial graphite broken into aggregate and asphalt which are kneaded and then roasted, or made of artificial graphite electrode and graphite block by processing.

4. A preparation method of the aluminum electrolytic cell having cathode carbon block with columnar protrusions embedded on its upper surface of Claim 1, wherein the method comprises the following steps:

(1) Using two methods to prepare the cathode carbon block substrate:

1) Extrusion method: when the cross section of the cathode carbon block substrate is a regular rectangular cross section, green compact of cathode carbon block substrate is prepared, the prepared green compact is prepared into anthracite or graphite cathode carbon block substrate after being roasted at 1100°C-1300°C or prepared into semi-graphitized cathode carbon block substrate after being roasted at 1100°C-1300°C or being heat-treated at 2300°C-2500°C, circular pot holes of 5-10cm in depth are machined in the positions where columnar protrusions are embedded of the upper surface of the cathode carbon block substrate, the side wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions;

2) Vibration molding or compression molding: when using vibration molding or compression molding to prepare the green compact of cathode carbon block substrate, the bottom surface of a heavy object on the material in the vibration molding mold is changed from a traditional plane into a structure with protrusions, or the bottom surface of a compression mold on the material in the mold is changed from a traditional plane into a structure having protrusions on its surface during compression molding; thus, after the cathode carbon block substrate is produced by vibration molding or compression molding, the upper surface of the green compact of the cathode

carbon block substrate which is formed by vibration molding or compression molding has pot holes used for arranging the columnar protrusions; wherein the distribution locations of the protrusions on the bottom surface of the heavy object on the material in the mold or the mold bottom surface of the material in the mold correspond to the locations of the columnar protrusions embedded on the upper surface of the cathode carbon block substrate; the shape of the protrusions is consistent with that of the pot holes for arranging the columnar protrusions embedded on the upper surface produced by vibration molding or compression molding; the depth of the pot holes is 5-10cm; when the cathode carbon block substrate is an anthracite cathode carbon block substrate, a graphite cathode carbon block substrate or a semi-graphite cathode carbon block substrate, the green compact of the above cathode carbon block is roasted at 1100°C-1300°C to be prepared into a cathode carbon block substrate with pot holes; when the cathode carbon block substrate is a graphitized or a semi-graphitized cathode carbon block substrate, the roasting method and the method for making the pot holes are the same as those used in method 1), the cathode carbon block substrate is heat-treated at 2300°C-3000°C in a graphitizing furnace after being roasted to be prepared into a semi-graphitized or a fully-graphitized cathode carbon block substrate; the pot holes in the upper surface of the cathode carbon block substrate are divided into circular pot holes and square pot holes; when the pot holes are circular pot holes, the inner wall of each pot hole is machined with internal threads, and the internal threads are matched with the external threads of the cylindrical columnar protrusions; when the pot holes are square pot holes, the inner wall of each pot hole is provided with at least four circular pits with the diameter of not less than 5mm and depth of not less than 10mm;

(2) Embedding columnar protrusions: thermosetting resin is mixed with graphite powder to prepare graphite paste, and the mix proportion is required to be capable of mixing paste; the graphite paste is filled into the pot holes; the columnar protrusions are arranged into the pot holes, wherein when the columnar protrusions are cuboid, the pot holes are square pot holes, the length and the width of the pot holes are 1-10mm more than the length and the width of

the columnar protrusions, and the cuboid columnar protrusions are vertically compressed into the pot holes; when the columnar protrusions are cylindrical, the pot holes are circular, and the side wall of each pot hole is machined with internal threads; the external threads of the columnar protrusions are matched with the internal threads of the pot holes, the columnar protrusions are screwed in the pot holes, and graphite paste is filled in the gap between the internal threads and the external threads; after the columnar protrusions are arranged into the pot holes, a part of the graphite paste in the pot holes is extruded out from the gap between the protrusions and the pot holes, and then is accumulated at the junction of the upper surface of the cathode carbon block substrate and the columnar protrusions.

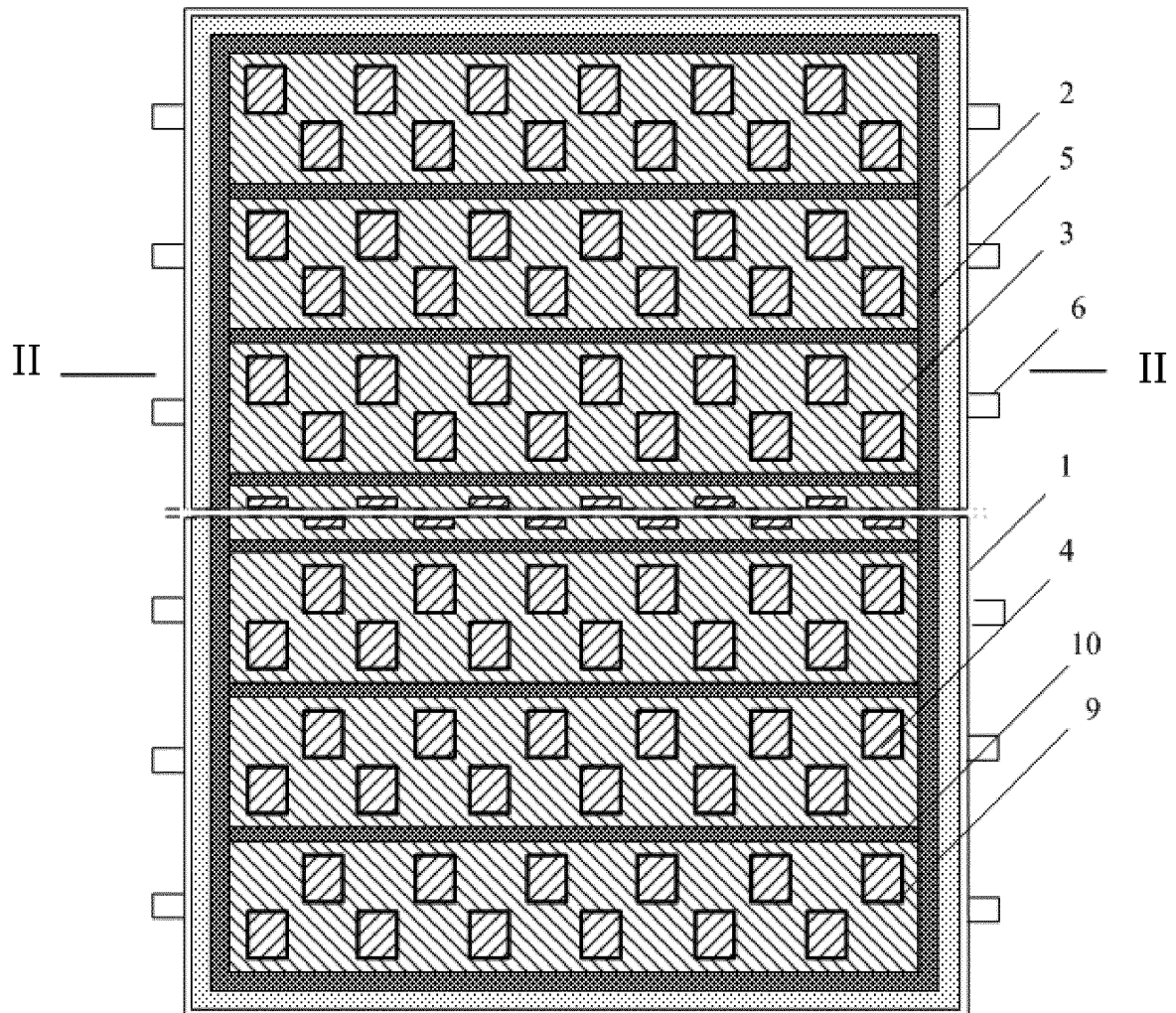


Figure 1

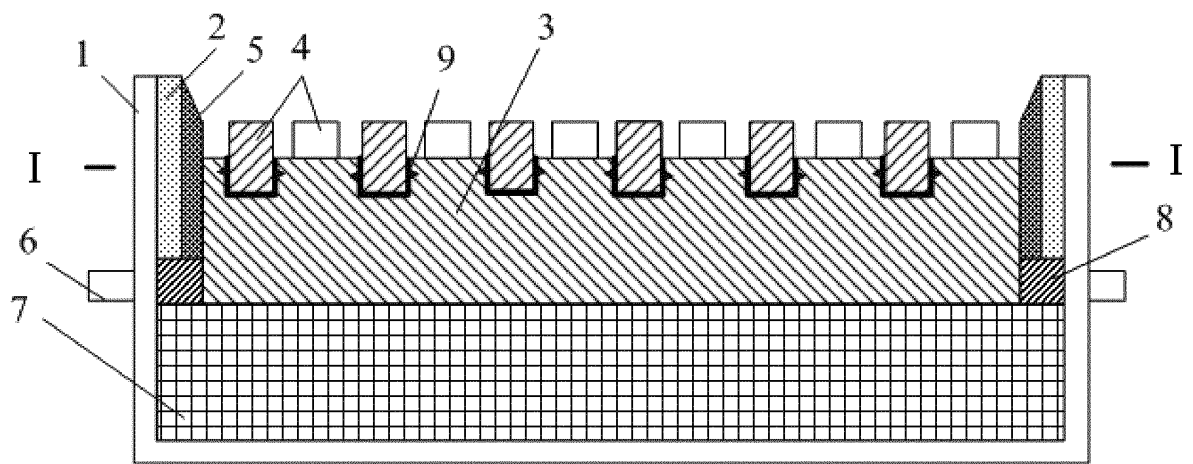


Figure 2

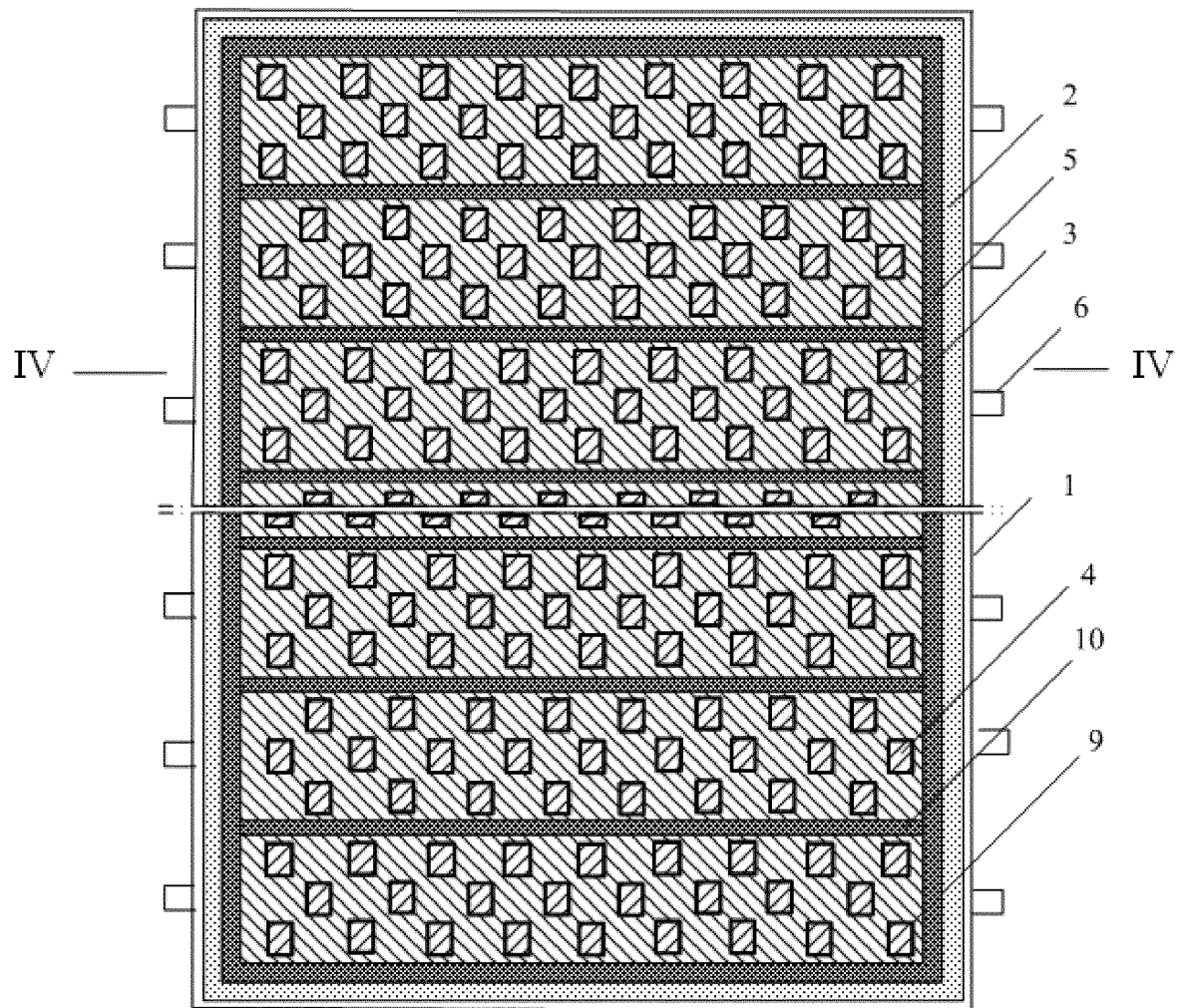


Figure 3

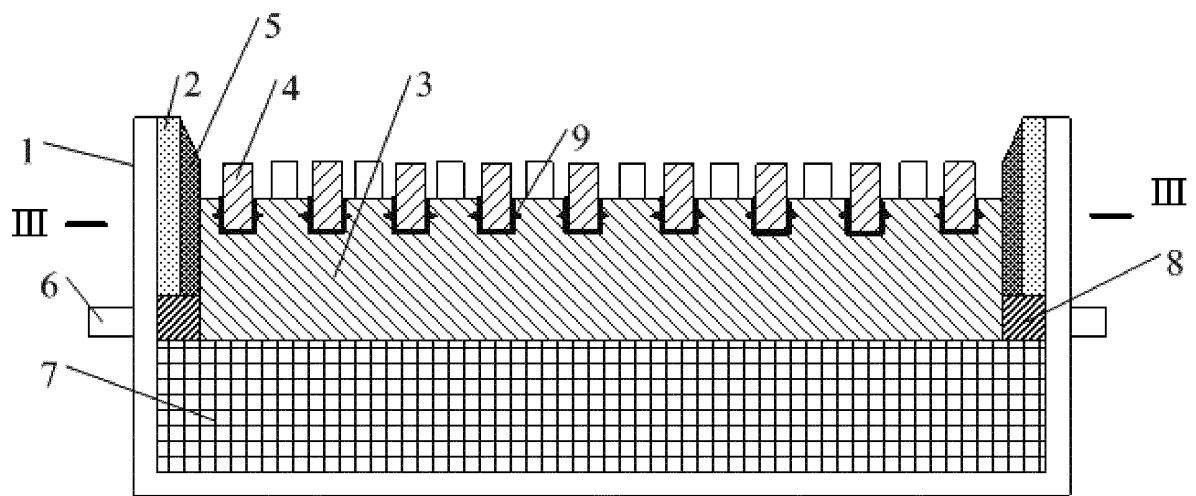


Figure 4

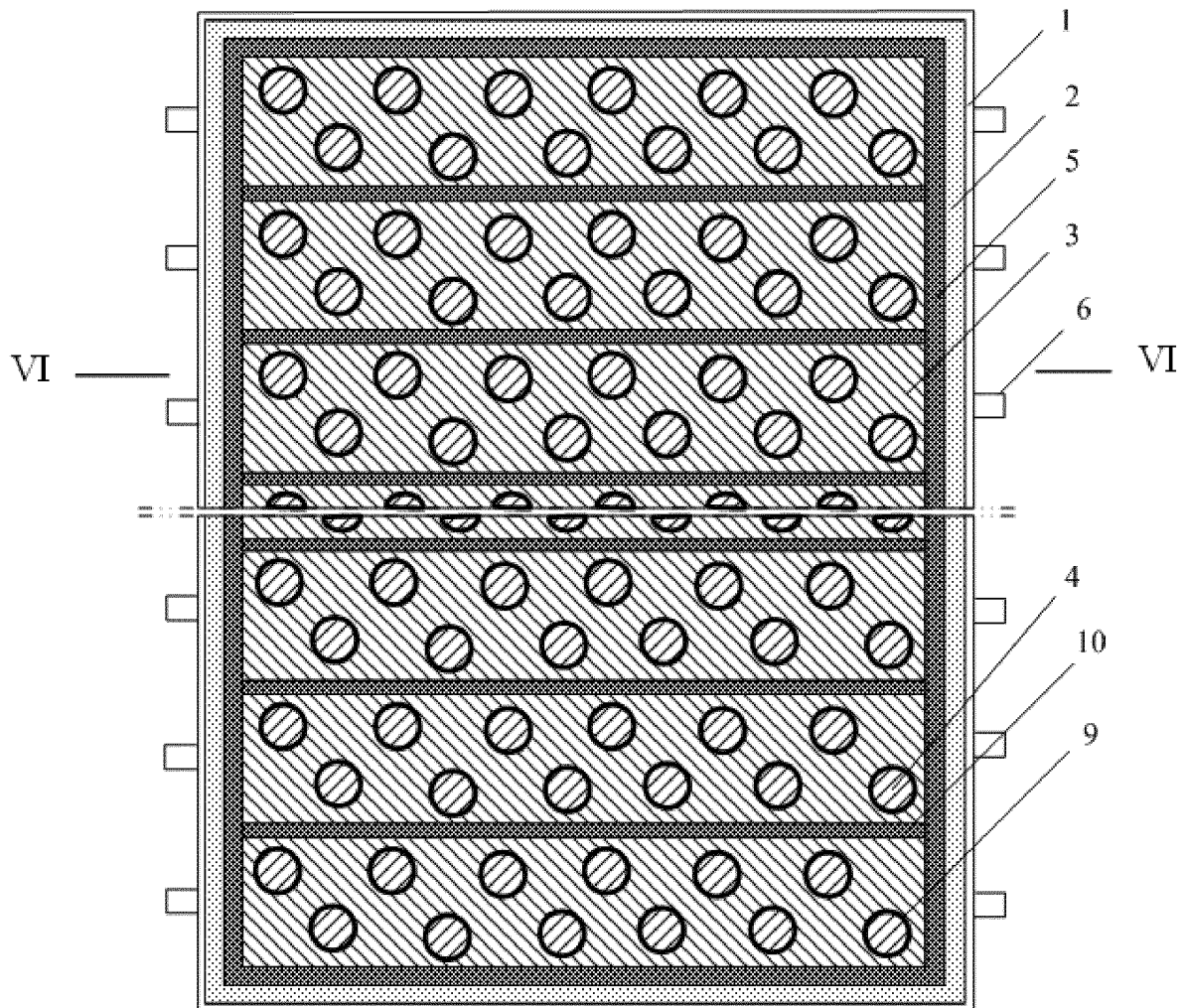


Figure 5

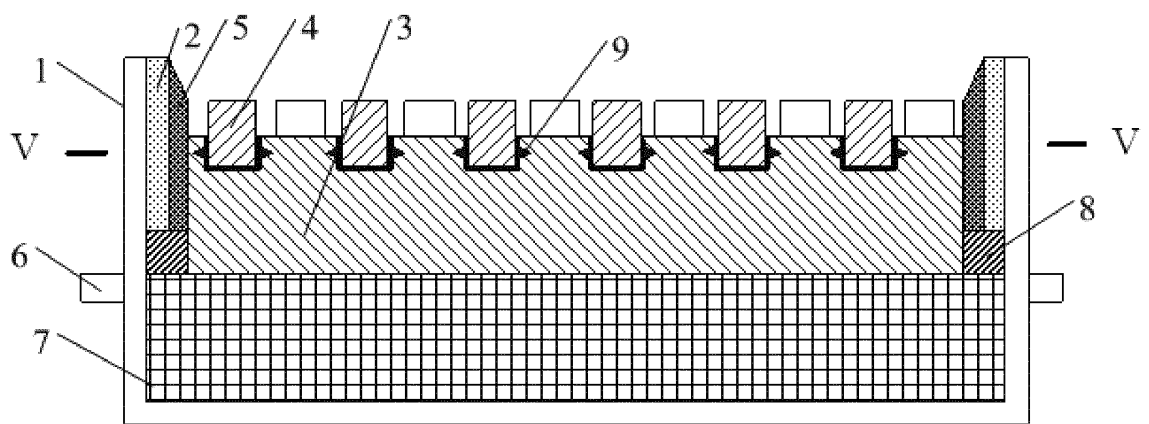


Figure 6

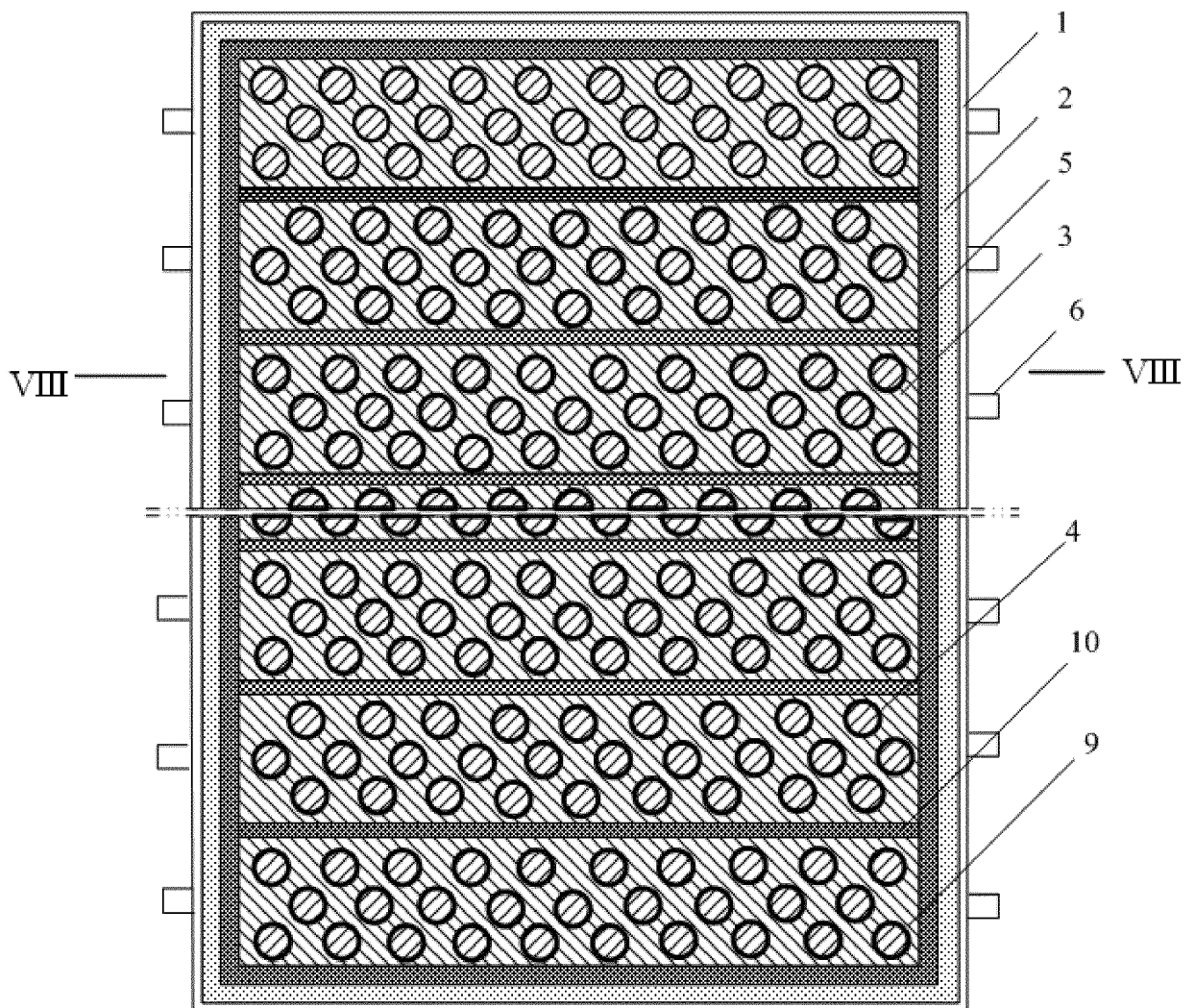


Figure 7

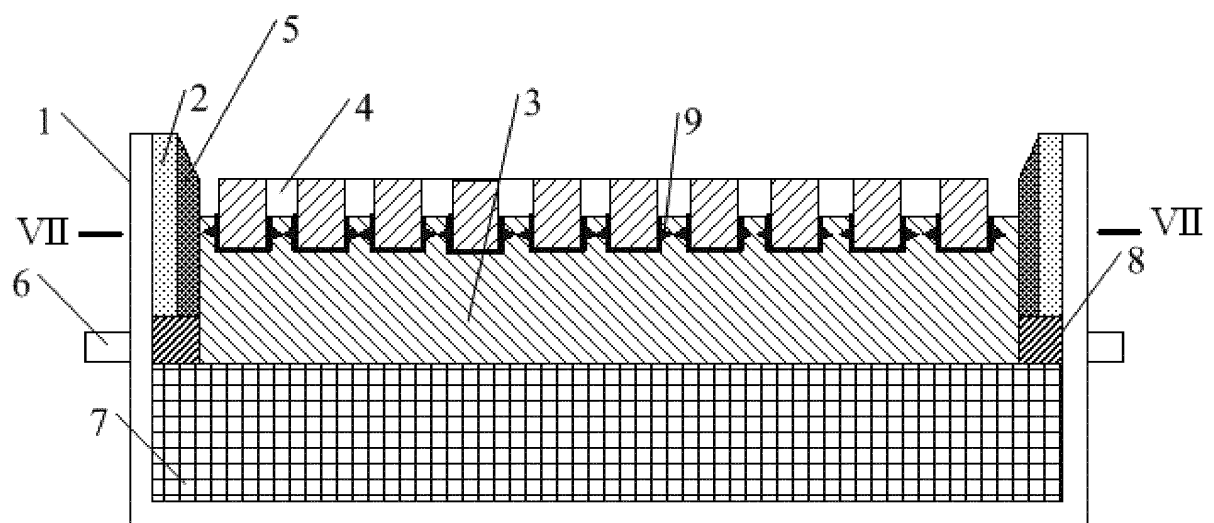


Figure 8

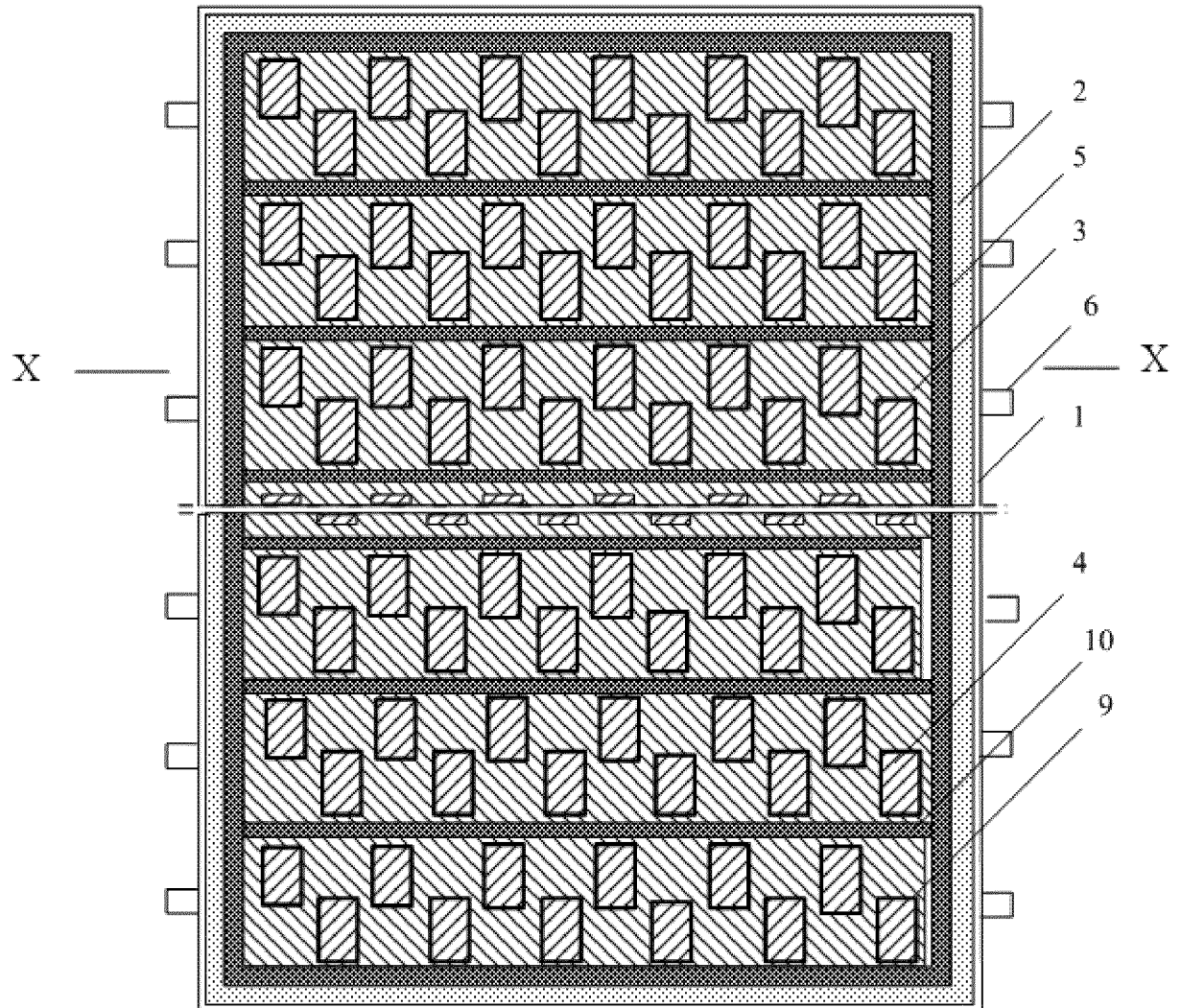


Figure 9

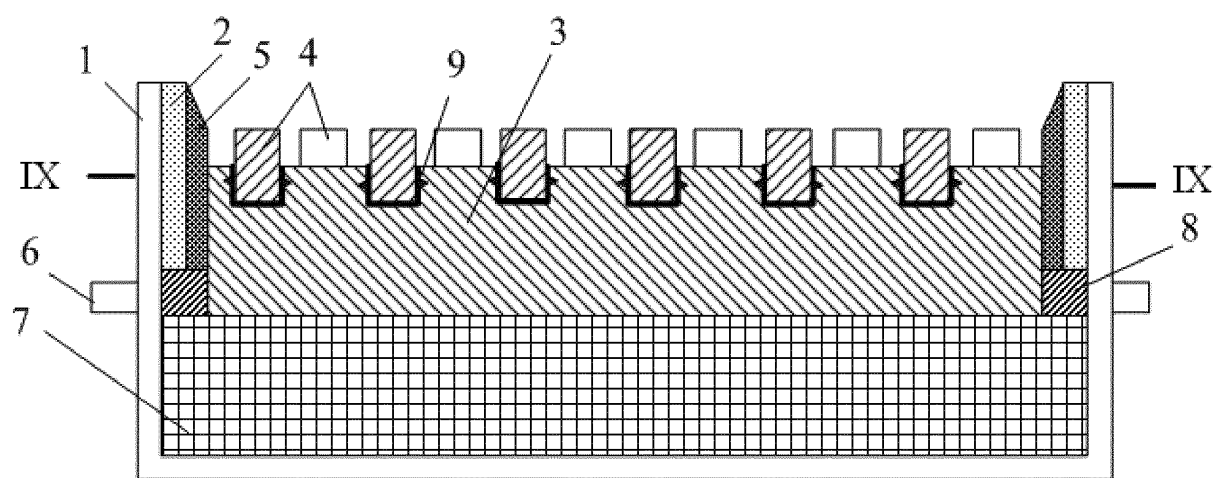


Figure 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/075575

A. CLASSIFICATION OF SUBJECT MATTER

C25C3/08(2006.01)j

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: C25C3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI, CNPAT, WPI, EPODOC: cathode?, block?, carbon, dam, bulg+, convex, boss, lug, lump, project+, belled, lobe, protrusion? swell, convex, heave, crowning, bump, embossment, raised, clutch, neck, chase, fluting, beard, saddleback+, protuberance, fillister, flute, gutter, ditch, bevell+, wavy, inclin+, irregular, abnormal, DEPRESS+, MOSAIC, INSERT+, ELBOW+, INLA??, ?EMBED+, ENCASE+, INBUILT+, BURIED, BUILTIN, RECESS+, CONCAVE, DITCH, DRAIN+, GROOVE, CHANNEL?, RECESS+, DENT+, NOTCH+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim
E	CN101851764A(GUIYANG ALUMINIUM MAGNESIUM ENG DESIGN & RES INS) 06 Oct. 2010 (06.10.2010), see its example 1 and figures 1- 3 of the description	1-6
X	CN201473604U(GUIYANG ALUMINIUM MAGNESIUM ENG DESIGN & RES INS) 19 May 2010 (19.05.2010), see its example 1 and figures 1- 3 of the description	1-6
X	CN201495298U(GUIYANG ALUMINIUM MAGNESIUM ENG DESIGN & RES INS) 02 June 2010 (02.06.2010), see its example and figures 1- 8 of the description	1-4
X	US4919782A(REYNOLDS METALS CO), 24 Apr. 1990 (24.04.1990), see its figures 1-3	1-4
X	US4631121A(REYNOLDS METALS CO [US]) 23 Dec. 1986 (23.12.1986), see its figures 1- 2	1-4

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

31 Mar. 2011(31.03.2011)

Date of mailing of the international search report

14 Apr. 2011 (14.04.2011)

Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

Authorized officer

MA, Xiufang

Telephone No. (86-10)62085177

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2010/075575

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101851764A	06.10.2010	none	
CN201473604U	19.05.2010	none	
CN201495298U	02.06.2010	none	
US4919782A	24.04.1990	none	
US4631121A	23.12.1986	none	

Form PCT/ISA /210 (patent family annex) (July 2009)