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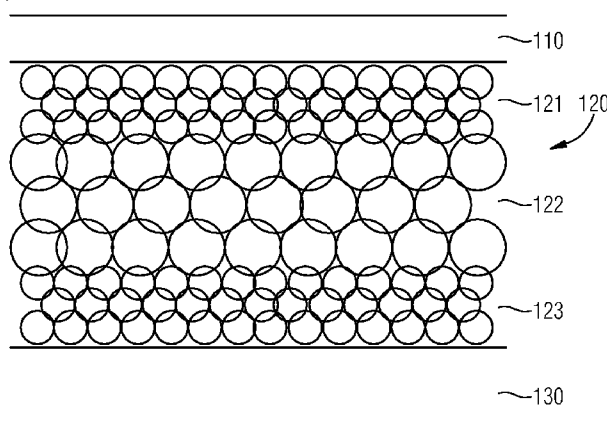
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(54) Title: LEAD FRAME AND METHOD FOR PRODUCING A LEAD FRAME

FIG 4



(57) Abstract: A metal lead frame (100) for an optoelectronic device (150) comprising three metal layers is disclosed. A first metal layer (110) comprises copper, a second metal layer (120) adjacent to the first metal layer comprises nickel and a third metal layer (130) adjacent to the second metal layer comprises silver. The second metal layer (120) comprises a first and a second sublayer (121, 122), which are adjoining and polycrystalline with a mean grain size each. The mean grain size of the first sublayer (121) differs more than 30 % from the mean grain size of the second sublayer (122). Moreover, an electronic device comprises such a lead frame. Additionally, a production method of such a lead frame is disclosed, comprising the steps: - Providing a copper lead frame; - galvanic deposition of nickel onto the copper lead frame; and - deposition of silver onto the nickel coated lead frame. The galvanic deposition of nickel is split into a first and a second process step with different deposition conditions, thus generating a first and a second polycrystalline sublayer. The mean grain size of the first sublayer differs more than 30 % from the mean grain size of the second sublayer.

LEAD FRAME AND METHOD FOR PRODUCING A LEAD FRAME

DESCRIPTION

5 The invention refers to a metal lead frame, a method of production of such a lead frame and an optoelectronic device with such a lead frame. Metal lead frames are usually made of copper, as copper is a suitable material for metal lead frames due to its thermal and electrical conductivity. To improve the metal lead frame, to improve particularly the ability to solder a device comprising such a lead frame, a silver layer is implemented on top of one side of the copper lead frame.

15 An assignment of the invention is to provide a new metal lead frame with improved mechanical properties. Another assignment of the invention is to provide an optoelectronic device with such a lead frame and a production method for such a lead frame.

20 The solution of these assignments is disclosed in the independent claims of this invention. Preferred embodiments are disclosed in the dependent claims.

25 A metal lead frame for an optoelectronic device is proposed, which comprises three metal layers, wherein a first metal layer comprises copper. A second layer adjacent to the first metal layer comprises nickel and a third metal layer adjacent to the second metal layer comprises silver. The implementation of a nickel layer between the copper and the silver suppresses the diffusion of copper atoms to the silver layer and thus suppresses the deterioration of the silver layer. The second metal layer, thus the nickel layer, comprises a first sublayer and a second sublayer. The nickel comprises a polycrystalline structure with a distribution of grain sizes around a mean grain size within each sublayer. The mean grain size is the arithmetic mean of the grain sizes of all grains forming the polycrystalline structure of the sublayer. The

first and the second sublayer are adjoining and the mean grain size of the first sublayer differs more than 30 % from the mean grain size of the second sublayer. Using this multiple grain structure will provide a higher ductility and an improved shear effect of the metal lead frame compared to the cracking problems obtained with a nickel layer with just one mean grain size. Thus the mechanical properties of this metal lead frame are improved.

In one embodiment the second metal layer comprises a third sublayer adjacent to the second sublayer. The third sublayer comprises a polycrystalline structure with a distribution of grain sizes around a mean grain size as well. The mean grain size of the third sublayer is similar to the mean grain size of the first sublayer. The composition of the nickel layer in this way further improves the mechanical properties of the metal lead frame with nickel and silver layer.

In one embodiment the mean grain size of the first sublayer varies from the mean grain size of the second sublayer by a range of 35 to 200 %, preferably 50 to 150 %, particularly preferably 75 % to 100 %. Differences in the mean grain sizes in that ranges are best suited for metal lead frames with good mechanical properties.

In one embodiment of the invention the mean grain size of the first sublayer is 20 nanometres and the mean grain size of the second sublayer is above 27 nanometres. With these mean grain sizes the mechanical properties of the metal lead frame are suitable to prevent cracking of the silver layer of the metal lead frame.

In one embodiment 90 % of the grains of any of the sublayers comprise a grain size within the range of 90 % to 110 % of the mean grain size. This leads to sublayers with well-defined mechanical properties.

A method for producing a metal lead frame comprises the steps:

- providing a copper lead frame;
- galvanic deposition of nickel onto the copper lead frame;

5 and

- deposition of silver onto the nickel coated lead frame, wherein the galvanic deposition of nickel is split into a first and a second process step with different deposition conditions, thus generating a first and a second polycrystal-
10 line sublayer with different mean grain sizes within the nickel layer. The mean grain size of the first sublayer differs more than 10 % from the mean grain size of the second sublayer. Using different conditions for the galvanic deposition of the nickel atoms leads to nickel sublayers with different mean grain sizes, thus leading to a nickel layer ac-
15 cording to the invention.

In one embodiment of the method the galvanic deposition of nickel is split into three process steps, wherein the deposition conditions for the first and third process step are similar. Therefore, three polycrystalline sublayers are generated, wherein the mean grain size of the third sublayer is similar to the mean grain size of the first sublayer.

25 In one embodiment of the method a current density during the galvanic deposition of the first step is different from a current density during the galvanic deposition of the second step. Modifying the current density leads to different mean grain sizes within the galvanically deposited nickel layers.

30

In one embodiment of the method an impulse-pause ratio of a current during the galvanic deposition of the first step is different from an impulse-pause ratio of a current during the galvanic deposition of the second step. Using pulsed currents
35 leads to improved properties of the nickel layer, compared to continuous current galvanic deposition. Changing the impulse-pause ratio of the pulsed current during the galvanic deposition leads to changed mean grain size of the nickel layer,

thus enabling nickel sublayers with different mean grain sizes.

In one embodiment a concentration of a grain refiner additive is different for the first step and the second step. The grain refiner additive leads to proper formation of the nickel layer. Changing the concentration of this grain refiner additive leads to different mean grain sizes of the sublayers established by the first step and the second step.

In one embodiment an impulse-reverse-pulse ratio of a current during the galvanic deposition of the first step is different from an impulse-reverse-pulse ratio of a current during the galvanic deposition of the second step. With an impulse-reverse-pulse ratio of the current impurities can be removed in situ within the galvanic deposition of the nickel layer. Changing the impulse-reverse-pulse ratio leads to different mean grain sizes and thus enables a nickel layer with sublayers with different grain sizes.

An optoelectronic device comprises a lead frame according to the invention. In one embodiment the optoelectronic device is embodied as a light-emitting device.

The above described properties, features and advantages of this invention as well as the method of obtaining them, will be more clearly and obviously understandable in the context of the following description of the embodiments, which are explained in more detail in the context of the figures.

In schematic illustration show

Fig. 1 a cross section through a metal lead frame with three layers, wherein the middle layer is subdivided into two sublayers;

Fig. 2 a cross section of a metal lead frame with three layers, wherein the middle layer is subdivided into three sublayers;

5 Fig. 3 a cross section of the middle layer;

Fig. 4 another cross section of the middle layer; and

Fig. 5 an optoelectronic device.

10

Fig. 1 shows a cross section through a metal lead frame 100. A first metal layer 110 comprises copper. A second metal layer 120 is located adjacent to the first metal layer 110 and comprises nickel. This second metal layer 120 is subdivided
15 into two sublayers 121 and 122. A first sublayer 121 is located adjacent to the first metal layer 110, a second sublayer 122 is located adjacent to the first sublayer 121 on the side of the sublayer 121 not adjoining the first metal layer 110. Adjoining to the second sublayer 122 of the second metal
20 layer 120 a third metal layer 130 is located. This third metal layer 130 comprises silver. The first sublayer 121 and the second sublayer 122 comprise a polycrystalline structure with a distribution of grain sizes around a mean grain size each. The mean grain size of the first sublayer 121 differs from
25 the mean grain size of the second sublayer 122 by more than 30 %. It is possible that the mean grain size of the first sublayer 121 is higher or lower than the mean grain size of the second sublayer 122 to improve the mechanical properties of the lead frame 100.

30

Fig. 2 shows a cross section of a metal lead frame 100 with a first metal layer 110, a second metal layer 120 and a third metal layer 130. The first metal layer is thereby located adjoining to the second metal layer 120, the second metal layer
35 120 is adjoining to the third metal layer 130. The second metal layer 120 is subdivided into three polycrystalline sublayers comprising a mean grain size each, a first sublayer 121, a second sublayer 122 and a third sublayer 123. The

first sublayer 121 adjoins the second sublayer 122, the second sublayer 122 adjoins the third sublayer 123. The first metal layer 110 comprises copper, the second metal layer 120 comprises nickel and the third sublayer 130 comprises silver.

5 The mean grain size of the first sublayer 121 and the third sublayer 123 are similar and differ from the mean grain size of the second sublayer 122 by at least 30 %.

10 In one embodiment the mean grain size of sublayer 121 varies from the mean grain size of the second sublayer 122 by a range of 35 to 200 %, preferably 50 to 150 %, particularly preferably 75 % to 100 %.

15 In one embodiment the mean grain size of the first sublayer 121 is 20 nanometres and the mean grain size of the second sublayer 122 is above 27 nanometres.

Fig. 3 shows a magnification of the second metal layer 120 with three sublayers 121, 122, 123 between the first metal layer 110 and the third metal layer 130. The grains of the polycrystalline nickel sublayers 121, 122 and 123 are schematically indicated by circles with different sizes. Other shapes of the grains, particularly polygonal shapes, occur in real sublayers. The grains within each sublayer 121, 122, 123 may also show a size distribution with a mean grain size represented by the size of the circles of fig. 3. The mean grain size of the first sublayer 121 is similar to the mean grain size of the third sublayer 123. The mean grain size of the second sublayer 122 differs from the mean grain size of the first sublayer 121 and the third sublayer 123, as the grains within the second sublayer 122 are bigger than the grains within the first sublayer 121 or the third sublayer 123. Thus the mean grain size of the second sublayer 122 is bigger than the mean grain size of the first sublayer 121 or the third sublayer 123.

Fig. 4 shows another magnification of the second metal layer 120 with three sublayers 121, 122, 123 between the first met-

al layer 110 and the third metal layer 130. In this Figure the mean grain size of the first sublayer 121 the second sublayer 122 and the third sublayer 123 are reversed compared to the sublayers 121, 122, 123 in Fig. 3. The grains of the polycrystalline nickel sublayers 121, 122 and 123 are schematically indicated by circles with different sizes. Other shapes of the grains, particularly polygonal shapes, occur in real sublayers. The grains within each sublayer 121, 122, 123 may also show a size distribution with a mean grain size represented by the size of the circles of fig. 4.

It is also possible that the grains within any of the three polycrystalline sublayers 121, 122, 123 comprise a size distribution which is a Gaussian distribution. This means that 68.27 % of the grains of the polycrystalline sublayer exhibit a grain size, which deviates from the mean grain size by less than one standard deviation. The standard deviation can be calculated from the grain sizes of all grains and the mean grain size.

Fig. 5 shows a cross section of an optoelectronic device with a first metal lead frame 151 and a second metal lead frame 152. The first metal lead frame 151 and the second lead frame 152 are composed of three metal layers, a first metal layer 110, a second metal layer 120 and a third metal layer 130. A magnification of the second metal layer 120 of the second metal lead frame 152 indicates that the second metal layer 120 is composed of a first sublayer 121, a second sublayer 122 and a third sublayer 123 with properties as described above. On top of the second metal lead frame 152, adjacent to the first metal layer 110 of the second lead frame 152 an optoelectronic chip 160 is located. A bond wire 170 connects the first metal lead frame 151 with the optoelectronic chip 160. The bond wire 170 is thereby bonded to the top side of the optoelectronic chip 160 opposite to the first metal layer 110 of the second metal lead frame 152. The other end of the bond wire 170 is bonded to the first metal layer 110 of the first metal lead frame 151. All components of this

optoelectronic device 150 are positioned within a housing 180, which could be made of a transparent mold material surrounding the other components during a mold process. Other materials and methods for generating the housing 180 are also possible. The third metal layer 130 of the first metal lead frame 151 and the second lead frame 152 are located on the bottom side of the optoelectronic device 150, thus forming solder pads for this optoelectronic device 150. As the third metal layer 130 consists of silver, these solder pads are well suited for proposed soldering the optoelectronic device 150 to a carrier. However, the lead frames 151, 152 can be used for any electric or electronic device.

In one embodiment, the size distribution of the grains within the first sublayer 121 is a Gaussian distribution around a mean grain size of 20 nanometres. The standard deviation of the grain size is 2 nanometres. This means that 68.27 % of the grains exhibit a grain size within the range of 18 to 22 nanometres. Other numeric values of the mean grain size and the standard deviation of the grain size are also possible.

To produce the metal lead frame 100 of Fig. 1, four subsequent steps are performed. In a first step, a copper lead frame is provided. This copper lead frame corresponds to the first metal layer 110 of Fig. 1. Subsequently, the second metal layer 120, particularly a nickel layer, is deposited galvanically onto the copper lead frame 110. This galvanic deposition of the nickel is subdivided into a first and a second process step with different deposition conditions. Therefore, the first polycrystalline sublayer 121 and the second polycrystalline sublayer 122 of the second metal layer 120 are generated. The mean grain size of the first sublayer 121 differs more than 30 % from the mean grain size of the second sublayer 122. In a concluding process step, a silver layer 130 is deposited onto the nickel coated lead frame, thus forming the metal lead frame 100 as shown in Fig. 1.

In one embodiment the galvanic deposition of the nickel to from the second metal layer 120 is subdivided into three process steps, forming the three polycrystalline sublayers 121, 122, 123. The result is then the metal lead frame 100 of Fig.

2. The deposition conditions of the first and the third process step are thereby similar, thus generating a first sublayer 121 and a third sublayer 123 with similar mean grain size. The mean grain size of the second sublayer 122 is different from the mean grain size of the first sublayer 121 and the third sublayer 123 due to different deposition conditions for the second process step compared to the first and third process step.

In one embodiment the different conditions within the process steps are due to a change of a current density during the galvanic deposition. An increased current density leads to an increased mean grain size. Therefore, alternating the current densities also leads to sublayers 121, 122, 123 within the second metal layer 120 with different mean grain sizes.

In one embodiment an impulse-pause ratio of a current during the galvanic deposition of the first step is different from an impulse-pause ratio of a current during the galvanic deposition of the second step, thus also leading to different mean grain sizes of the sublayers 121, 122, 123 formed within these process steps.

In one embodiment a concentration of a grain refiner additive during the galvanic deposition of the first step is different from a concentration of a grain refiner additive during the galvanic deposition of the second step. Increasing the grain refiner additive concentration leads to an increased mean grain size of the sublayers 121, 122, 123 established within these process steps. Therefore alternating the grain refiner additive concentrations leads to sublayers 121, 122, 123 with different mean grain sizes.

In one embodiment an impulse-reverse-pause ratio of a current during the galvanic deposition of the first step is different from an impulse-reverse-pause ratio of a current during the galvanic deposition of the second step. The reverse pulse in this method leads to removal of impurities within the nickel layer and thus to a more pure nickel layer. Changing the impulse-reverse-pause ratio also leads to different mean grain sizes of the sublayers 121, 122, 123 created within the corresponding process steps.

Although the invention was described and illustrated in more detail using preferred embodiments, the invention is not limited to these. Variants of the invention may be derived by a person skilled in the art from the described embodiments without leaving the scope of the invention.

REFERENCE NUMERALS

	100	metal lead frame
	110	first metal layer
5	120	second metal layer
	121	first sublayer
	122	second sublayer
	123	third sublayer
	130	third metal layer
10	150	optoelectronic device
	151	first lead frame
	152	second lead frame
	160	optoelectronic chip
	170	bond wire
15	180	housing

CLAIMS

1. A metal lead frame (100) for an optoelectronic device (150) comprising three metal layers (110, 120, 130),
5 wherein a first metal layer (110) comprises copper,
wherein a second metal layer (120) adjacent to the first metal layer (110) comprises nickel and wherein a third metal layer (130) adjacent to the second metal layer (120) comprises silver, characterized in that the second
10 metal layer (120) comprises a first and a second sublayer (121, 122), in that the first and second sublayer (121, 122) are adjoining, in that the first and second sublayer (121, 122) comprise a polycrystalline structure with a distribution of grain sizes around a mean grain size
15 each, and in that the mean grain size of the first sublayer (121) differs more than 30 % from the mean grain size of the second sublayer (122).
2. The metal lead frame (100) according to claim 1, wherein
20 the second layer (120) comprises a third sublayer (123) adjacent to the second sublayer (122), wherein the third sublayer comprises a polycrystalline structure with a distribution of grain sizes around a mean grain size, and wherein mean grain size of the third sublayer (123) is
25 similar to the mean grain size of the first sublayer (121).
3. The metal lead frame (100) according to any of the preceding claims, wherein the mean grain size of the first
30 sublayer (121) varies from the mean grain size of the second sublayer (122) by a range of 35 % to 200 %, preferably 50 % to 150 %, particularly preferably 75 % to 100 %.
- 35 4. The metal lead frame (100) according to any of the preceding claims, wherein the mean grain size of the first sublayer (121) is 20 nanometres and the mean grain size of the second sublayer (122) is above 27 nanometres.

5. The metal lead frame (100) according to any of the preceding claims, wherein the size distribution of the grains within any one of the sublayers (121, 122, 123) is a Gaussian distribution.
6. A method for producing a metal lead frame according to any of the preceding claims, comprising the steps:
- Providing a copper lead frame;
 - galvanic deposition of nickel onto the copper lead frame; and
 - deposition of silver onto the nickel coated lead frame,
- characterized in that the galvanic deposition of nickel is split into a first and a second process step with different deposition conditions, thus generating a first and a second polycrystalline sublayer with different mean grain sizes, wherein the mean grain size of the first sublayer differs more than 30 % from the mean grain size of the second sublayer.
7. The method according to claim 6, wherein the galvanic deposition of nickel is split into the first, the second and a third process step, wherein the deposition conditions for the first and third process step are similar, thus generating three polycrystalline sublayers, wherein the mean grain size of the third sublayer is similar to the mean grain size of the first sublayer.
8. The method according to any of the claims 6 or 7, wherein a current density during the galvanic deposition of the first step is different from a current density during the galvanic deposition of the second step.
9. The method according to any of the claims 6 to 8, wherein an impulse-pause ratio of a current during the galvanic deposition of the first step is different from an im-

pulse-pause ratio of a current during the galvanic deposition of the second step.

- 5 10. The method according to any of the claims 6 to 9, wherein a concentration of a grain refiner additive during the galvanic deposition of the first step is different from a concentration of a grain refiner additive during the galvanic deposition of the second step.
- 10 11. The method according to any of the claims 6 to 10, wherein an impulse-reverse-pulse ratio of a current during the galvanic deposition of the first step is different from an impulse-reverse-pulse ratio of a current during the galvanic deposition of the second step.
- 15 12. An optoelectronic device (150) with a lead frame (100, 151, 152) according to any of the claims 1 to 5.
- 20 13. The optoelectronic device (150) according to claim 12, which is embodied as a light emitting device.

FIG 1

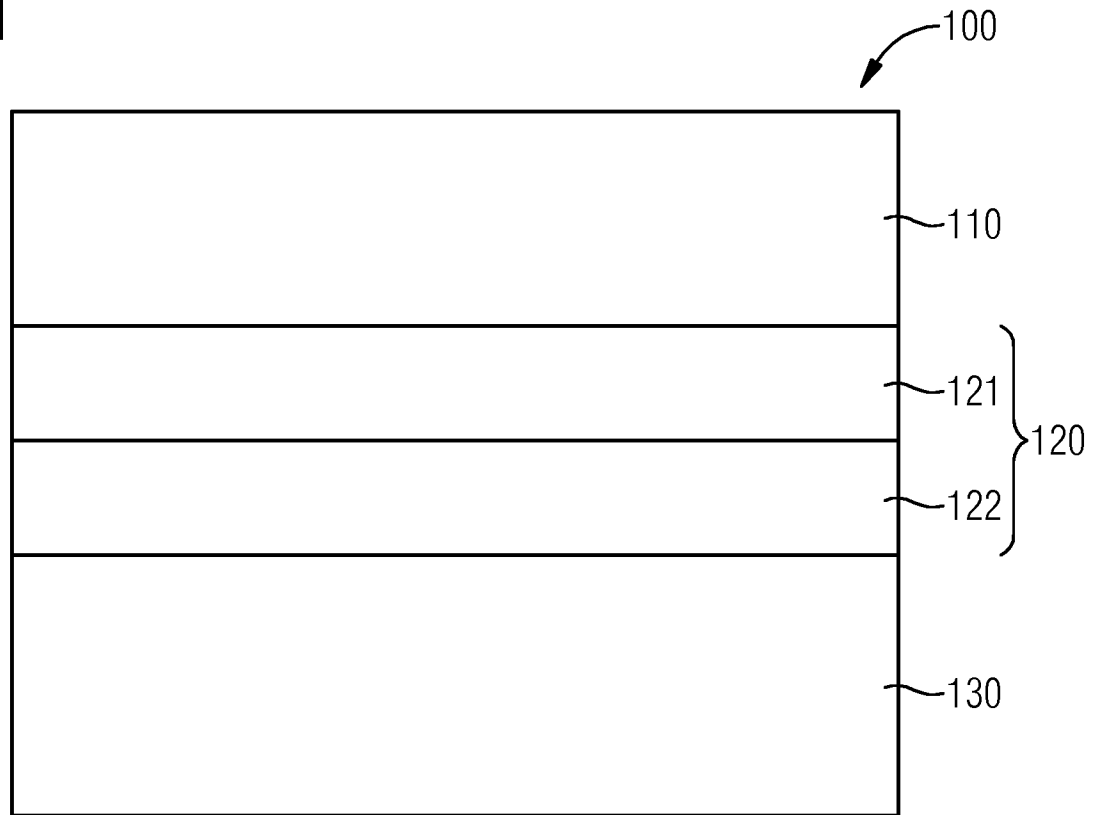


FIG 2

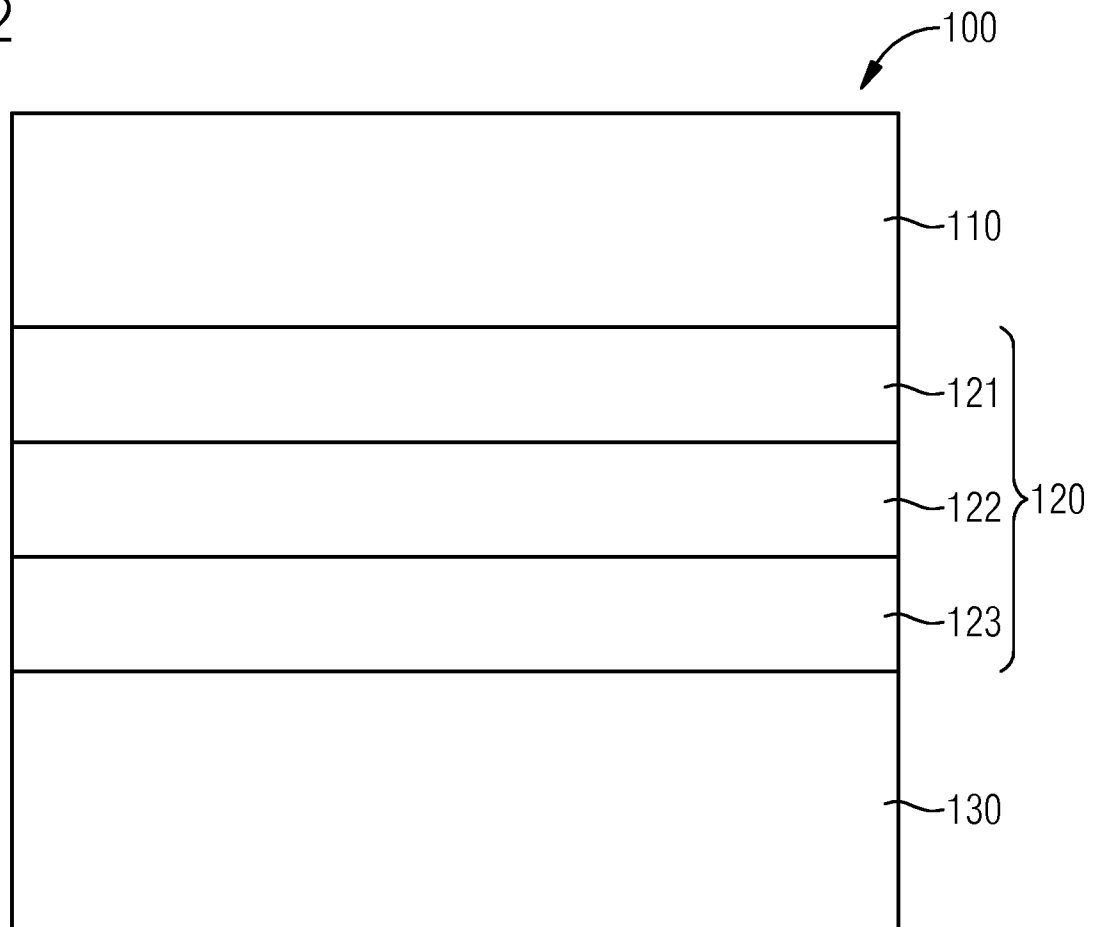


FIG 3

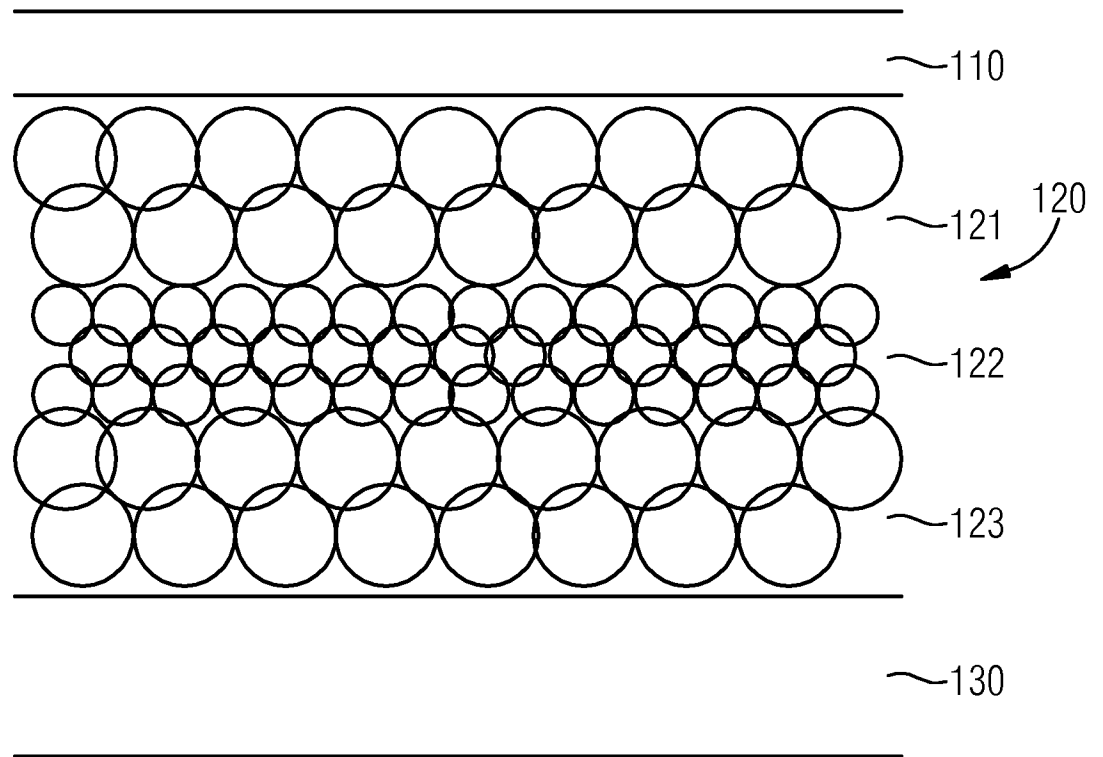


FIG 4

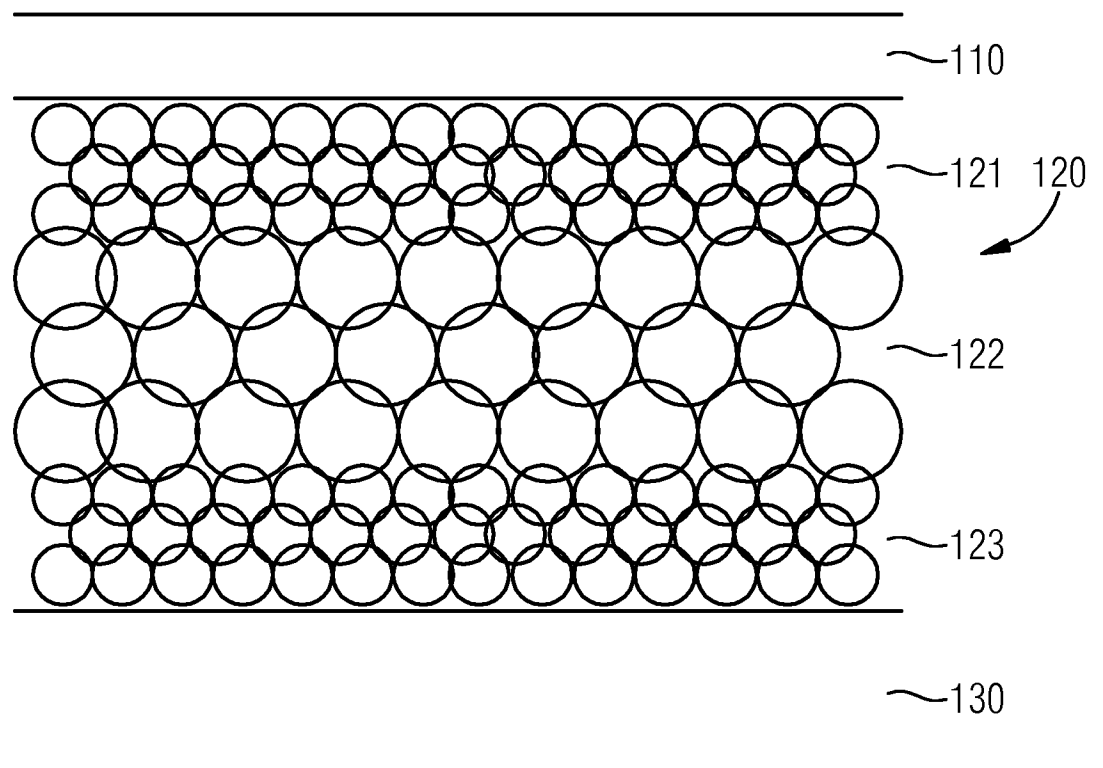
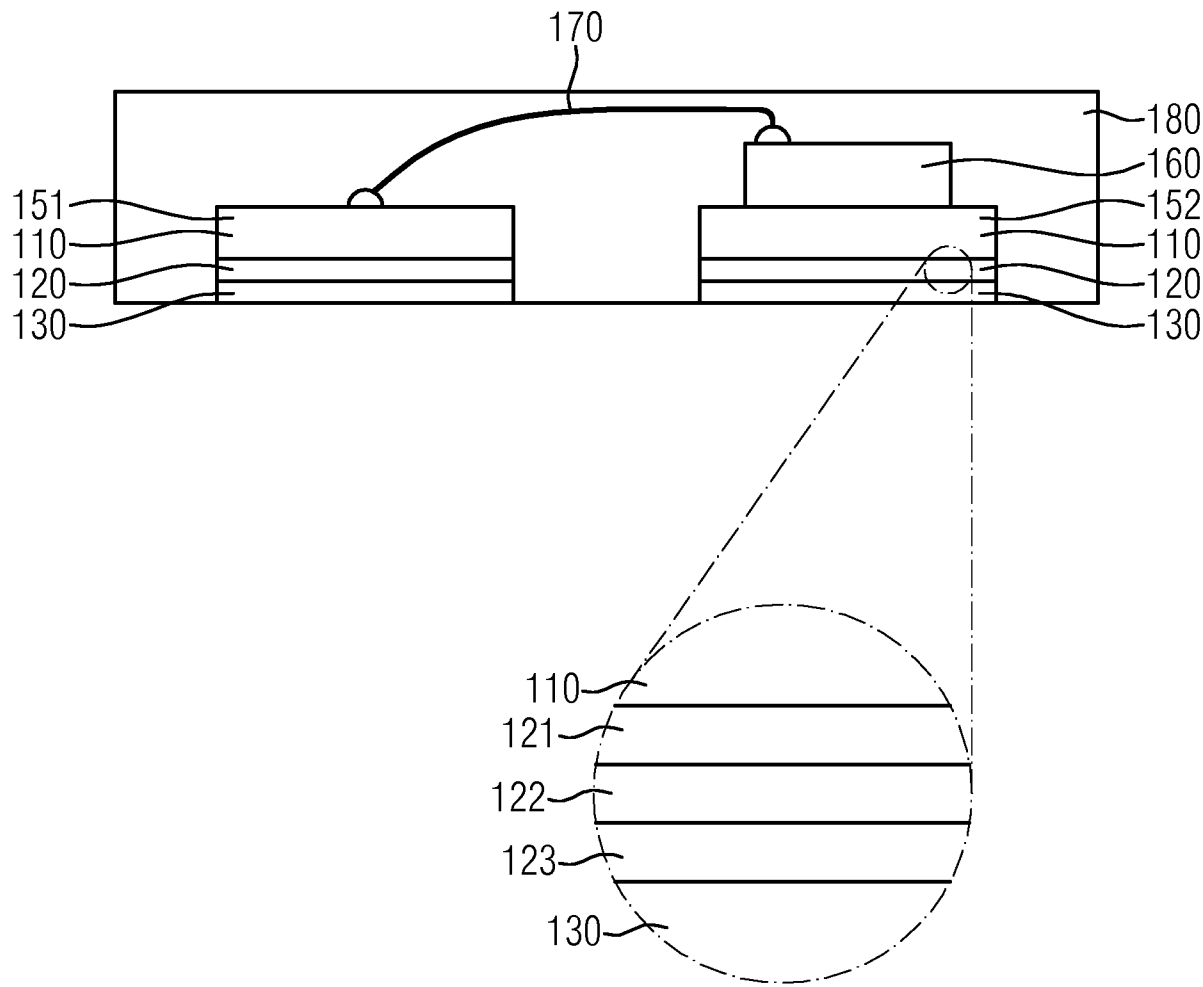


FIG 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/052180

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L33/62 H01L23/495
ADD. C25D3/12 C25D5/14 C25D5/18

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)
H01L C25D

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 5 333353 B2 (SUMITOMO METAL MINING CO) 6 November 2013 (2013-11-06) paragraph [0014]; figures 1(a)-1(b) paragraph [0015] - paragraph [0019]; figures 2(a)-2(f) paragraph [0022] - paragraph [0026]; example 1 -----	1-13
A	US 2015/194585 A1 (KIM KYOUNGMIN [KR] ET AL) 9 July 2015 (2015-07-09) paragraph [0070] -----	1,6
Y	US 2013/328070 A1 (HUSSELL CHRISTOPHER P [US] ET AL) 12 December 2013 (2013-12-12) paragraph [0057] - paragraph [0062]; figure 8A paragraph [0034]; figure 3 ----- -/-	1-5,12, 13



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

14 July 2016

Date of mailing of the international search report

26/07/2016

Name and mailing address of the ISA/

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Franssen, Gijs

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/052180

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/042708 A1 (NIHEI NORIKO [JP] ET AL) 24 February 2011 (2011-02-24) paragraph [0011] paragraph [0020] - paragraph [0032]; figures 2A, 2B -----	1-5,12, 13
A	US 2011/121326 A1 (TAN KIA KUANG [MY] ET AL) 26 May 2011 (2011-05-26) paragraph [0041] - paragraph [0055]; figures 1-4 -----	1-5,12, 13
A	US 2015/076545 A1 (NAKATANI SEIICHI [JP] ET AL) 19 March 2015 (2015-03-19) paragraph [0041] - paragraph [0070]; figures 1A-1G -----	1,3-5, 12,13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/052180

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 5333353	B2	06-11-2013	CN 102971845 A 13-03-2013
			JP 5333353 B2 06-11-2013
			JP 2012004186 A 05-01-2012
			KR 20130036017 A 09-04-2013
			TW 201214645 A 01-04-2012
			WO 2011158731 A1 22-12-2011
US 2015194585	A1	09-07-2015	KR 20150083151 A 17-07-2015
			US 2015194585 A1 09-07-2015
US 2013328070	A1	12-12-2013	NONE
US 2011042708	A1	24-02-2011	JP 5329341 B2 30-10-2013
			JP 2011044477 A 03-03-2011
			US 2011042708 A1 24-02-2011
US 2011121326	A1	26-05-2011	NONE
US 2015076545	A1	19-03-2015	CN 104272446 A 07-01-2015
			JP 5521130 B1 11-06-2014
			US 2015076545 A1 19-03-2015
			WO 2014034024 A1 06-03-2014