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(71) Applicant *(for all designated States except US)*: **STMICROELECTRONICS S.R.L.** [IT/IT]; Via C. Olivetti, 2, I-20864 Agrate Brianza (MB) (IT).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **CREMA, Paolo** [IT/IT]; Via C. Olivetti, 2, I-20864 Agrate Brianza (MB) (IT).

(74) Agent: **PFAU, Anton**; Grünecker, Kinkeldey, Stockmair & Schwanhäusser, Leopoldstrasse 4, 80802 München (DE).

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(54) **Title**: METHOD AND APPARATUS FOR MANUFACTURING LEAD FRAMES

(57) **Abstract**: The present invention relates to a method and an apparatus for manufacturing lead frames. According to the present invention, a coating layer (120) is formed on one or more predefined portions (A, B, C, D, E, F, G, H) of the surface (110s) of the substrate (100) of the lead frame (100) by delimiting the predefined portions (A, B, C, D, E, F, G, H) by means of screen printing. The employment of screen printing allows the obtainment of large amounts of lead frames with excellent electronic and structural properties in a quick and cost-effective way.

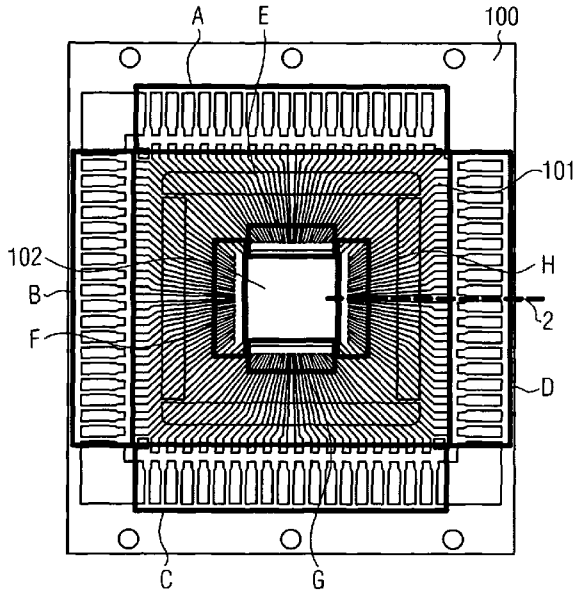

FIG. 1

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METHOD AND APPARATUS FOR MANUFACTURING LEAD FRAMES

TECHNICAL FIELD OF THE INVENTION

The present invention relates to the field of integrated circuits. In particular, the present invention relates to the manufacturing process of lead frames for integrated circuits. Yet more specifically, the present invention concerns a method and an apparatus for manufacturing lead frames by means of screen printing.

STATE OF THE ART

One of the main problems when fabricating lead frames for integrated circuits concerns the need for optimizing system performances while, at the same time, reducing or, at least, restraining production costs.

Lead frames consist of a metal substrate, also known as base metal, usually covered with one or more covering metal layers.

The substrate is usually made of copper, copper alloys, steel, iron and nickel alloys, or nickel and steel alloys (invar). The substrate is produced by a metal sheet which is patterned by means of punching, cutting or chemical etching, so as to form the components of the lead frames such as the conducting segments and the area for housing the semiconductor devices. These semiconductor devices are then electrically connected to the conducting elements by means of wire bonding and are mechanically mounted onto the housing area of the system by means of encapsulation with plastic materials or resins.

Lead frames have thus to guarantee both high solderability for implementing electrical connections, and optimal adhesion to the encapsulating material which encloses the semiconductor devices.

It has been observed that the substrate is not able to possess these properties. For instance, in the case of a copper substrate, formation of corrosion products such as oxides or sulphides on the substrate surface has been observed. The presence of these corrosion products deteriorates the substrate solderability.

For this reason, the idea of plating the substrate with one or more covering metal layers has

been put forward, so as to guarantee clear areas with excellent and stable solderability. In particular, precious metals such as palladium, silver and gold have been used for forming coating layers with high and stable solderability. Examples of such structures for lead frames can be found in EP0335608B1.

However, using these precious metals for coating the substrate has caused the cost of lead frames to increase dramatically. In particular, coating the entire surface of the substrate of lead frames with one or more layers of precious metals, such as palladium or gold, requires considerable amounts of such metals.

In order to overcome this problem, a procedure for selectively depositing the coating layers (selective plating) has been suggested. In particular, due to this approach, the coating layers of precious metal are deposited only on predetermined areas of the substrate, so as to reduce the system surface occupied by precious metals, while guaranteeing high solderability only in those areas which are actually designed for bonding, for example only at the end of the conduction means. This enables up to 60-75 per cent saving of precious metal used with respect to the configuration with total coating. An example of a configuration wherein palladium is selectively deposited in predetermined areas of the substrate can be found in US7,064,008 B2. A further example can be found in US7,504,712 B2.

Although the selective plating of precious metals has enabled a reduction in lead frame manufacturing costs, since the amount of precious metals used has been reduced, the methods used so far for implementing the selective plating display several disadvantages and problems.

One of the methods initially used for implementing the selective plating of precious metals is based on mechanical screening systems (for example metal masks) adapted to screen those substrate areas which do not have to be coated with precious metals and, thus, to leave those areas which have to be coated with precious metals free. However, by using these mechanical masks, a high degree of precision cannot be guaranteed, since the precious metals which are deposited by plating are likely to leak through the gaps which inevitably form between the mask and the substrate. This causes both the plating to be inaccurately implemented and the precious metals to be wasted.

Moreover, using mechanical masks carries the risk of damaging the lead frame substrate owing to the pressure exerted by the mask on the substrate.

In order to overcome problems arising from using mechanical masks, the proposal has been put

forward to produce masks made of a photoresist and to use laser light for exposing those substrate areas upon which the coating layers have to be selectively deposited. An example of such a solution can be found in US4,877,644A.

However, using photoresist is costly, since these materials are costly. Furthermore, the procedure for removing the photoresist from the predetermined areas in which the plating is performed is lengthy and slow and, thus, it considerably slows down the speed of lead frame manufacturing. Furthermore, in these techniques, the relative motion between the laser beam and the photoresist-covered-substrate is achieved by moving the substrate and keeping the direction of the laser beam fixed. Due to this reason, this method cannot be used for producing lead frames according to reel-to-reel or strip-to-strip processes.

In order to obviate these problems, in WO 00/52231 the option of using low-cost electrophoretic materials for implementing the mask has been proposed. According to WO 00/52231, the layer of electrophoretic material is selectively removed by driving a laser beam with wavelength of 400 nm to 1200 nm across the surface by means of an optical galvo system. The method described in WO 00/52231 is nevertheless slow and decreases the speed of production of lead frames.

As it clearly turns out from these facts, it is necessary to develop a method for manufacturing lead frames which is able to overcome the problems outlined above. In particular, a method for manufacturing lead frames is required which guarantees optimal properties of the lead frames produced, while being fast and cost-effective, so as to reduce lead frame manufacturing costs and to increase their manufacturing speed.

The present invention as defined by the attached claims allows for achieving these goals.

SUMMARY OF THE INVENTION

The present invention concerns a method and an apparatus for manufacturing lead frames. The present invention is based on the idea of using screen printing for manufacturing lead frames. In particular, the present invention is based on the idea of delimiting by means of screen printing those predefined areas of the substrate which are to be plated. This allows for providing lead frames with optimal properties in an effective and economical way.

According to an embodiment of the present invention, a system is provided for manufacturing lead frames comprising a metal substrate, wherein the method comprises the formation of at least one coating layer on ore or more predetermined portions of the surface of the substrate and wherein the formation of at least one coating layer on one or more predetermined portions

of the surface of the substrate comprises the delimitation of said one or more predetermined portions by means of screen printing. Using screen printing for delimiting predetermined portions of the surface upon which the coating layer is deposited, allows for considerably speeding up the lead frame manufacturing process and for reducing manufacturing costs, since the materials used for screen printing are not costly.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein screen printing consists of rotary screen printing. Rotary screen printing allows for further speeding up and facilitating the lead frame manufacturing process.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein screen printing comprises the following steps: formation of a screen printing mesh comprising a plurality of holes; occlusion of one or more holes of the screen printing mesh so that the screen printing ink is allowed to come out through the screen printing mesh and cover the substrate so as to leave said one or more predetermined portions of the surface of the substrate exposed. The screen printing mesh can comprise a plurality of holes. For example, the screen printing mesh can comprise a plurality of holes with the same shape and/or dimension. The holes can have hexagonal shape. The holes can have dimensions of the order of 30 micrometres.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the screen printing mesh is made of metal, preferably of nickel, steel or nickel-plated steel. Metals are particularly convenient since they can be patterned by photoengraving or by means of laser-based techniques so as to form the holes in the mesh. In particular, nickel is a particularly stable material. Furthermore, nickel can be easily patterned by means of laser-based techniques so as to form extremely fine meshes, for example 75 to 400 holes per square inch (1 square inch is equal to 6.4516 cm^2).

According to an embodiment of the present invention, the nickel mesh has an approximate thickness of about over 80 micrometres and comprises a plurality of hexagonal holes having dimension of 27 micrometers and an opening area of 17%.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the occlusion is achieved by means of gelatine.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided further comprising the following steps: spreading the screen printing mesh

with the gelatine so as to occlude the holes of the screen printing mesh, polymerization of the gelatine occluding one or more predetermined holes, stripping non polymerized gelatine off the screen printing mesh so as to clear the holes occluded by non polymerized gelatine.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the delimitation comprises the formation of a screening mask on the surface of the substrate and the screening mask is such that said one or more predetermined portions of the surface of the substrate are exposed so as to allow the coating layer to be deposited onto them. The screening mask allows in an easy and effective way for delimiting those portions onto which the coating layer is to be deposited, for example, by plating.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the screening mask comprises one or more of the following materials: epoxy materials or acrylic materials.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided which further comprises curing of the screening mask. In this manner, the screening mask is steadily attached to the substrate and it is strengthened so as to prevent the material from being wasted due to leaks through gaps likely to occur between the mask and the substrate.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein curing is carried out by means of UV-radiation. Curing by means of UV-radiation is particularly effective with respect to material which can be used as screen printing ink.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided which further comprises stripping for removing the material deposited by means of screen printing from the substrate.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided which further comprises a substrate pre-treatment so as to remove impurities from the substrate, said pre-treatment being carried out before the predetermined areas of the substrate upon which the coating layer is to be formed, are delimited.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the formation of at least a coating layer on ore or more predetermined portions of the surface of the substrate comprises plating with one or more metal

layers. For example, metals such as nickel, palladium, gold and silver can be plated.

According to a further embodiment of the present invention, a method for manufacturing lead frames is provided wherein the coating layer comprises one or more metals. For example, multi-layer coatings can be implemented which are particularly effective for guaranteeing high and stable solderability.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames according to the method according to the present invention is provided, wherein the apparatus comprises a screen printing press.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided wherein the screen printing press consists of a rotary screen printing press.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided wherein the screen printing press comprises a metallic screen printing mesh.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided wherein the metallic screen printing mesh comprises at least one of the following materials: nickel, steel, nickel-plated steel. The screen printing mesh can have thickness between 50 and 100 micrometres, preferably 80 micrometres.

According to a further embodiment of the present invention, the screen printing mesh is made of nickel and comprises a plurality of holes with regular hexagonal shape and dimension between 25 micrometres and 30 micrometres, preferably 27 micrometres.

According to a further embodiment of the present invention, at least one or more of the holes of the mesh are occluded by means of gelatine.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided further comprising a station for curing the material deposited by means of the screen printing press.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided wherein the curing station comprises a system for irradiating UV-light.

According to a further embodiment of the present invention, an apparatus for manufacturing lead frames is provided which is adapted to carry out a reel-to-reel process. Reel-to-reel processes enable fast and effective large scale production of lead frames.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will be described by referring to the attached figures, in which identical and/or similar and/or corresponding parts are identified by the same reference numbers or letters. In the figures:

Fig. 1 schematically shows a lead frame seen from above;

Fig. 2 schematically shows the cross section of the portion of the lead frame which corresponds to the dashed line shown in Fig. 1;

Fig. 3 schematically shows the flow-chart of a method for manufacturing lead frames according to an embodiment of the present invention;

Fig. 4 schematically shows the results of each single step of the method according to the flow-chart shown in Fig. 3.

Fig. 5 schematically shows an apparatus according to an embodiment of the present invention.

DETAILED DESCRIPTION

In the following, the present invention will be described by referring to particular embodiments as shown in the figures. However, the present invention is by no means limited to the particular embodiments described in the detailed description below. Rather, the particular embodiments described in what follows clarify some aspects of the present invention, whose scope is defined by the claims.

Further modifications or variations of the present invention will be clear to the skilled person. Consequently, the present description is to be considered as inclusive of all said modifications and/or variations of the present invention, whose scope is defined by the claims.

Fig. 1 schematically shows a lead frame 100 which can be obtained according to an embodiment of the present invention. The lead frame 100 comprises a plurality of conducting elements 101 and a housing area 102 adapted to house semiconductor devices such as, for example, chips and integrated circuits. The conducting elements 101 are used for electrically connecting the devices housed in the housing area 102 with, for example, other electronic systems in the architecture of a printed circuit board.

Fig. 1 schematically shows those predetermined portions A, B, C, D, E, F, G and H of the

substrate of the lead frame 100 which are plated. In particular, in the example shown in Fig. 1, the ends of the conducting elements 101 are plated. The predetermined portions E, F, G and H correspond to the inner ends of the conducting segments 101, i.e. to the ends of the conducting elements facing the housing area 102. These ends are adapted to be electrically connected, for example by means of wire bonding, to the devices housed in the housing area 102.

The predetermined portions A, B, C and D correspond to the outer ends of the conducting elements 101, i.e. to the ends of the conducting elements 101 on the side opposite to the ends facing the housing area 102. These ends can, for example, be connected by means of welding to other electronic systems in the architecture of a complex system.

As shown in Fig. 1, the predetermined portions A, B, C, D, E, F, G and H identify a limited portion of the surface of the lead frame substrate and, therefore, enable the selective plating, i.e. restricted to those predetermined portions. In this manner, a considerable amount of material to be deposited for plating can be saved, with respect to methods based on full plating of the substrate. In particular, it is possible to save up to 75% of material deposited for plating with respect to the configuration with full plating. This allows for considerably reducing the costs for lead frame manufacturing, especially in the case in which the material deposited for plating is one or more precious metals.

Fig. 2 schematically shows the cross section of that portion of lead frame which corresponds to the dashed line shown in Fig. 1. For the sake of simplicity, Fig. 2 is not shown in scale with respect to Fig. 1.

Fig. 2 shows the metal substrate 110. The metal substrate 110 is also referred to as base metal. The substrate metal 110 can be made, for example, of copper, steel, iron and nickel alloys, or nickel and steel alloys (invar). The substrate 110 comprises a surface 110s.

As depicted in Fig. 2, some predetermined portions of the substrate 110 are coated with a coating layer 120. In particular, the predetermined portions coated with the coating layer shown in Fig. 2 correspond to areas H and D schematically shown in Fig. 1.

The coating layer 120 can consist of a single metal layer. Alternatively, the coating layer 120 can consist of a multi-layer structure comprising one or more metal layers. Metals which can be used for the coating layer 120 can comprise, for example, one or more of the following materials: nickel, palladium, silver, gold, silver and gold alloys.

For example, a coating layer 120 can be implemented which comprises a nickel layer in direct

contact with the substrate 110, a palladium layer on top of the nickel layer, a silver layer on top of the palladium layer and a gold layer on top of the silver layer. According to a further example, the coating layer 120 can comprise a nickel layer in direct contact with the substrate 110, a palladium layer on top of the nickel layer and a gold layer on top of the palladium layer.

The areas of the surface 110s of the substrate 110 which are not plated, i.e. which are not coated by the coating layer 120, can also be rough as schematically shown in Fig. 2 so as to improve, for example, adhesion with plastic materials or resins used for encapsulating the devices housed in the housing area 102 of the lead frame.

In particular, the substrate 110 can undergo a roughening process, for example by means of chemical, electrochemical or thermal processing, before carrying out the deposition of the coating layer 120. The substrate, thus roughened, subsequently undergoes the processes for forming the coating layer 120 which will be accurately described in what follows. During these processes, the areas screened by the screening mask remain unaltered and, thus, rough, whereas the areas exposed for receiving the coating layer 120 by plating are flattened, for example by the plating processes.

In this way, after carrying out the formation of the coating layer 120, the areas which are not coated by the coating layer 120 are rough as shown in Fig. 2 and are therefore particularly convenient for improving adhesion of the substrate 110 with encapsulating materials used for encapsulating the devices housed in the housing area 102.

Fig. 3 shows schematically the flow-chart of a method 200 for manufacturing lead frames according to an embodiment of the present invention, and Fig. 4 shows schematically the results of each step of the method according to the flow-chart shown in Fig. 3.

In the first step 201 of the method 200, the pre-treatment of the metal substrate 110 is carried out. In particular, the metal substrate 110 which is pre-treated at step 201 has been previously patterned so as to form the lead frame structure. The metal substrate 110 which is pre-treated at step 201, thus comprises the conducting segments and the housing area for housing the electronic devices. These structures can be obtained starting from a metal sheet by using known techniques, for example by means of punching and cutting.

The pre-treatment 201 allows the surface 110s of the substrate 110 to be cleaned, i.e. to be cleared of all possible contaminants on the surface. In particular, the pre-treatment allows for removing oxides and grease from the surface 110s of the substrate 110.

The pre-treatment 201 can comprise, for example, a bath for removing oil from the surface 110s of the substrate 110. Furthermore, the pre-treatment 201 can comprise electro-cleaning processes so as to remove organic compounds from the surface 110s of the substrate 110 and to reduce the roughness of the surface. Furthermore, the pre-treatment 201 can comprise chemical etching processes for removing oxides from the surface. Air blows and rinsing in water can also be applied to the substrate 110 before and after each process of the pre-treatment 201 for removing chemicals used in the process which might remain and for preventing the substrate from being contaminated again.

In the second step 202 of the method 200, those portions of the substrate 110 are delimited which are to be subsequently coated with the coating layer 120. Basically, in the second step 202 a selective coating is performed. In particular, in the second step 202 the screening mask 301 in the surface of the substrate 110 is formed. The screening mask 301 allows for delimiting the portions of the substrate upon which the coating layer 120 is to be subsequently formed. In particular, the screening mask 301 is such that it leaves the substrate portions upon which the coating layer 120 is to be subsequently formed exposed. As depicted in Fig. 4, the screening mask 301 is such as to leave the portions H and D of the surface of the substrate 110 exposed.

Furthermore, in the example shown in Fig. 4, the screening mask 301 covers also the entire lower surface of the substrate 110. This can be convenient, for instance, for so called Lead Tips of the lead frame, i.e. for the ends facing the housing area 102. These areas can be plated on one of the two surfaces only, in order to favour the subsequent wire bonding.

The screening mask 301 can be made of epoxy materials, acrylic materials or a mixture of epoxy and acrylic materials.

The screening mask 301 is formed on the substrate 110 by means of screen printing. An example of the formation process of the screening mask 301 according to an embodiment of the present invention will be described in detail below.

In the third step 203 of the method 200, curing of the material deposited on the substrate 110 by means of screen printing at step 202 is performed. In particular, as shown in the example depicted in Fig. 4, curing of the screening mask 301 formed by means of screen printing at step 202 is performed so as to form the cured screen printing mask 301'.

Curing can be achieved by exposing the system to ultraviolet radiation. For example, the system can be exposed to radiation with wavelength of 300 nm or smaller. The system can be exposed

for 3-5 seconds to a radiation of 350 mJ/cm^2.

In the fourth step 204 of the method 200 plating is carried out. In particular, in the fourth step 204 the formation of the coating layer 120 is carried out. This can be achieved by means of known techniques, for example by means of electrodeposition.

In the example shown in Fig. 4 the coating layer 120 comprises three layers: 121, 122 and 123. The three layers can be sequentially obtained by means of subsequent depositions by electrodeposition. The layer 123 in direct contact with the substrate 110 can be, for example, a nickel layer. The layer 122 on top of the layer 123 can be a palladium layer. The layer 121 on top of the palladium layer can be a gold layer.

In the fifth step 205 of the method 200 stripping off of the cured material formed in steps 202 and 203 is carried out. The cured screening mask 301' can be removed by means of, for example, alkali solutions. For instance, a 3% solution of sodium hydroxide can be used.

In the following, the delimitation 202 of one or more predetermined portions of the substrate 110 by means of screen printing will be described in detail according to an embodiment of the present invention.

The screen printing press comprises a screen printing mesh. The screen printing mesh defines the areas through which the material acting as screen printing ink can penetrate. Therefore, the screen printing mesh reflects the substrate areas which are screened by the mask obtained by screen printing.

The screen printing mesh can consist of a very fine net comprising a plurality of holes with the same shape and dimensions. The dimensions of the holes can vary in the range from a few tens to a few hundreds of micrometres. Preferably, the holes can have a diameter of the order of 30 micrometres, for instance 27 micrometres.

The screen printing mesh can be made, for example, of steel, nickel-plated steel, nickel or polyester. Metallic materials are particularly convenient since they can easily be photoengraved or engraved by means of laser-based techniques so as to obtain extremely fine meshes, for example 75 to 400 holes per square inch. Furthermore, metallic materials are such that their thickness does not affect the dimensions of the hole opening.

The screen printing mesh can, thus, be produced starting from a metal sheet which is patterned by laser-based techniques so as to obtain a predefined mesh.

The screen printing mesh can be conveniently implemented in nickel. Nickel enables extremely small holes. Furthermore, nickel is a particularly stable material. For instance, holes with dimension of 27 micrometres can be obtained. The holes can have hexagonal shape. For example, the holes can have regular hexagonal shape. In this case, the hexagonal holes can be such that the diameter of the circle inscribed in the hexagon is of the order of 30 micrometres, preferably 27 micrometres.

The nickel sheet can have, for example, thickness of 80 micrometres.

The opening area, i.e. the ratio of total surface occupied by the holes to total surface of the mesh, can be of 17%.

Predetermined areas of the screen printing mesh are occluded by means of gelatines. For example, emulsions or photosensitive products can be used. In particular, the gelatines can comprise photosensitive acrylic or epoxy polymer-matrices. The gelatines can be such that, after being photo-polymerized, they are resistant to inks used in screen printing so as not to be damaged or removed by the presence of the screen printing inks.

Basically, some predetermined holes of the mesh are occluded with gelatine. In this manner, the positive image of the coating structure 120 to be deposited on the lead frame is obtained on the screen printing mesh. In other words, those holes of the screen printing mesh are occluded with gelatine, which correspond to the regions of the lead frame which are to be exposed so that the coating layer 120 can be deposited upon them, for example by means of plating.

The photosensitive gelatine in semi-liquid form can be spread across the whole surface of the screen printing mesh by means of a roller or squeegee. In this manner, the semi-liquid gelatine homogeneously occupies all holes in the screen printing mesh. The system is subsequently exposed to a light beam, for example to ultraviolet radiation, after being covered by an appropriately designed mask so as to leave exposed only those portions of gelatine which are to be polymerized and, thus, made stable by means of the light beam. After exposing the system covered by the mask to the light beam, the gelatine occupying the holes corresponding to openings in the mask is polymerized. Conversely, the gelatine occupying the holes covered by the mask during the exposure to the light beam is not polymerized. This residual non polymerized gelatine is then removed by means of aqueous solutions or solvents. In this manner, the holes of the screen printing mesh with non polymerized gelatine are cleared of the gelatine and, thus, opened. The holes of the screen printing mesh with polymerized gelatine are, conversely, still occluded since polymerized gelatine is not removed by the aqueous solutions

used for removed non polymerized gelatine.

The polymerized gelatine stays therefore steadily in the holes of the screen printing mesh. In order to change the image produced and, thus, to modify the shape and/or the dimensions of the coating structure 120, it is necessary to modify the screen printing mesh, for example by removing the polymerized gelatine or by replacing the screen printing mesh with a new one. Polymerized gelatine can be removed from the holes by means of stripping with appropriate solvents, for example chlorinated solvents.

The material making up the screening mask acts as ink for screen printing. Typical materials which can be used as screen printing ink according to the present invention include epoxy materials, acrylic materials or materials formed by a mixture of epoxy and acrylic materials. Additives can also be added, so as to adjust the rheology of the ink. Furthermore, additives can be added to serve as photo-initiators.

The screen printing ink is then let through the screen printing mesh. Basically, the screen printing ink is pushed so as to let it through those holes which are not occluded by gelatine only. In this manner, the negative image of the coating structure 120 to implement is produced on the lead frame. In other words, the screen printing ink is deposited on the lead frame substrate so as to leave exposed those areas of the substrate upon which the coating structure is to be formed. The screen printing ink forms therefore the screening mask 301 on the lead frame substrate.

According to a particular embodiment of the present invention, the screen printing is of rotary type. In this case, a screen printing mesh as described above is mounted onto the printing roller. The printing roller is hollow and is filled with screen printing ink. The printing roller can be provided with a squeegee roller adapted to force the screen printing ink through the non occluded holes of the screen printing mesh.

One or more substrates of lead frame placed on a dedicated belt are slid across the roller surface. In particular, the system can be provided with a press roller so that the belt supporting the substrate is pressed against the surface of the press roller. In particular, the belt supporting the lead frame substrate is lead between the printing and the press roller.

When the substrate is in contact with the surface of the roller, the ink is let out of the screen printing mesh so as to form the screening mask on the substrate.

Active control on the motion of the press roller allows, for example, for compensating misalignments which may occur between the reproduction step of the desired image and the

lead frame substrates on the belt.

Fig. 5 schematically shows an apparatus 400 for producing lead frames according to an embodiment of the present invention.

The system is adapted to carry out a reel-to-reel process. In particular, the system comprises a supply reel 401. The supply reel 401 is loaded with a belt 500 upon which the lead frame substrates are mounted.

The belt 500 is driven from the supply reel 401 to the station 402 for the delimitation 202 of the predetermined portions of the substrate upon which the coating layer is to be formed. In particular, the station 402 comprises a screen printing press. In the example shown in Fig. 5, the screen printing press is a rotary screen printing press, whose cylinder 402b and press roller 402a are schematically depicted.

The station 402 also comprises a station 402c for curing the material deposited on the lead frame substrate by the screen printing press. For example, the station 402c for curing can comprise a system for ultraviolet radiation.

At the station 402, therefore, the cured mask 301' is formed on the lead frame substrate.

The belt 500, from the station 402, reaches subsequently the cleaning station 403. At this station the substrate is cleaned. In particular, the exposed areas, upon which the coating layer 120 will be deposited, are cleaned. For example, at this station residual oily impurities or organic contaminants of the substrate can be removed. This cleaning procedure is carried out with substances adapted to not corrode or damage the cured masked 301'. For instance, it is preferable to use substances with pH less than 10.

From the cleaning station 403, the belt is sent to the activation station 404. At this station, the substrate is cleared of oxides which might form, for example of copper oxides in case of copper substrate. Furthermore, a thin layer film of substrate material can be removed by chemical etching, so as to expose the layers of material underneath, which are more active and, thus, facilitate the subsequent plating. Activation can be achieved, for example, by means of acid solutions and selective oxidizing agents for the material of which the substrate is made.

Subsequently, the belt 500 is moved to the plating block 405. The plating block 405 is used for forming the coating layer 120. The plating block 405 can comprise one or more stations for plating, each station being adapted to perform plating with a specific type of metal. The plating

stations can be adapted to perform, for example, plating by electrodeposition. In the example shown in Fig. 5, the plating block 405 comprises three stations for plating: 405a, 405b and 405c. The station 405a can, for example, be adapted to perform plating with nickel. The station 405b can, for example, be adapted to perform plating with palladium. The station 405c can be adapted to perform plating with gold and/or silver.

After plating at the block 405, the belt 500 moves to stripping 406. At this station, the material deposited on the substrate by means of screen printing at block 402 is removed.

After stripping at the station 406, the belt reaches the station for drying 407. Drying conveniently removes residual traces of water which might persist from the system. In particular, this residual water might oxidize the substrate, thus damaging its properties by forming, for example, discolorations.

Finally, the belt 500, which at this stage carries the complete lead frames, is wound by the take-up-reel 408.

Although not explicitly shown in Fig. 5, cleaning means for removing residual impurities which might result from the previous station can be present between the pairs of indicated stations. For instance, it is possible to carry out one or more rinses after each station. Furthermore, it is possible to further clean the system after each station with an air blow.

Furthermore, after stripping at the station 406, it is possible to include a high-pressure wash so as to facilitate removing the cured mask 301'.

The reel-to-reel system 400 with a screen printing press allows for considerably increasing the lead frame production rate. For example, production rates of 10-30 m/min can be achieved. It is also possible to achieve production rates of 50 m/min. At the same time, lead frames thus manufactured are guaranteed to have excellent electronic and structural properties.

Although the present invention has been described with reference to the embodiments presented above, it is clear to the skilled person that several modifications, variations or improvements of the present invention according to the teaching described above and within the scope of the attached claims can be designed, without departing from the object and the scope of protection of the invention.

For example, although it has been shown that the predetermined lead frame areas upon which the coating is formed are the ends of the lead frame conducting elements, it is possible to

choose these predetermined areas in any position of the substrate.

Furthermore, according to the present invention, it is also possible to structure the coating layer so that it is formed by a plurality of metal layers with different shapes. In particular, it is possible to form a first coating layer by plating after making a first screening mask by screen printing. After forming the first coating layer, it is possible to remove the first screening mask by stripping and to make, by screen printing, a second screening mask with a different structure from the first mask so as to form a second coating layer with, for example, dimensions and/or shapes different from the first coating layer. This procedure can be repeated several times so as to form a multi-layer coating wherein each layer has specific dimensions and/or shapes which can be, for example, different from those of the other layers.

Furthermore, even though in the examples shown above a treatment with a single belt (single strand treatment) has been described, it is also possible to work with two or more than two belts in parallel (double strand, multiple strands treatment). In this manner, the lead frame production rate is further accelerated.

In addition to that, areas which are known to the skilled person have not been described in order to avoid any unnecessary complication when describing the present invention.

Consequently, the invention is not restricted to the embodiments described above, but is uniquely restricted to the scope of protection of the attached claims.

CLAIMS

1. Method for manufacturing lead frames (100) comprising a metal substrate (110), said method comprising the following step: formation of at least one coating layer (120) on ore or more predetermined portions (A, B, C, D, E, F, G, H) of the surface (110s) of said substrate (110), characterised in that: said formation of at least one coating layer (120) on one or more predetermined portions (A, B, C, D, E, F, G, H) of the surface (110s) of said substrate (110) comprises a delimitation (202) of said portions (A, B, C, D, E, F, G, H) by means of screen printing.

2. Method according to claim 1, wherein said screen printing consists of rotary screen printing.

3. Method according to one of the claims 1 or 2, wherein said screen printing comprises the following steps:

formation of a screen printing mesh comprising a plurality of holes;

occlusion of one or more of said holes so that the screen printing ink is allowed to come out through said screen printing mesh and cover said substrate (100) so as to leave said one or more predetermined portions (A, B, C, D, E, F, G, H) of the surface (110s) of said substrate (110) exposed.

4. Method according to claim 3, wherein said screen printing mesh is made of metal, preferably of nickel, steel, or nickel-plated steel.

5. Method according to one of claims 3 or 4, wherein said occlusion is achieved by means of gelatine.

6. Method according to claim 5, further comprising the following steps:

spreading said screen printing mesh with said gelatine so as to occlude the holes of said screen printing mesh,

polymerization of the gelatine occluding one or more predetermined holes,

removal of the non polymerized gelatine from said screen printing mesh so as to clear the holes occluded by non polymerized gelatine.

7. Method according to any of claims 1 to 6, wherein said delimitation (202) comprises the formation of a screening mask (301) on the surface (110s) of said substrate (110), wherein said screening mask (301) is such that said one or more predetermined portions (A, B, C, D, E, F, G, H) of the surface (110s) of said substrate (110) are exposed so as to enable deposition of said coating layer (120) onto them.

8. Method according to claim 7, wherein said screening mask (301) comprises one or more of the following materials: epoxy materials, or acrylic materials.

9. Method according to one of claims 7 or 8 further comprising curing (203) of said screening mask (301).

10. Method according to claim 9, wherein said curing (203) is carried out by means of UV-radiation.

11. Method according to one of claims 1 to 10, further comprising stripping (205) for removing the material deposited by means of screen printing from said substrate (110).

12. Method according to one of claims 1 to 11, wherein said formation of at least a coating layer (120) on one or more predetermined portions (A, B, C, D, E, F, G, H) of the surface (110s) of said substrate (110) comprises plating (204) with one or more metal layers (121, 122, 123).

13. Apparatus (400) for manufacturing lead frames according to the method of one of claims 1 to 12, wherein said apparatus (400) comprises a screen printing press (402a, 402b).

14. Apparatus according to claim 13, wherein said screen printing press (402a, 402b) consists of a rotary screen printing press.

15. Apparatus according to one of claims 13 or 14, wherein said screen printing press comprises a metallic screen printing mesh.

16. Apparatus according to claim 15, wherein said metallic screen printing mesh comprises at least one of the following materials: nickel, steel, nickel-plated steel.

17. Apparatus according to one of claims 13 to 16 further comprising a station (402c) for curing the material deposited by means of said screen printing press.

18. Apparatus according to one of claims 13 to 17, wherein said apparatus is adapted to

carry out a reel-to-reel process.

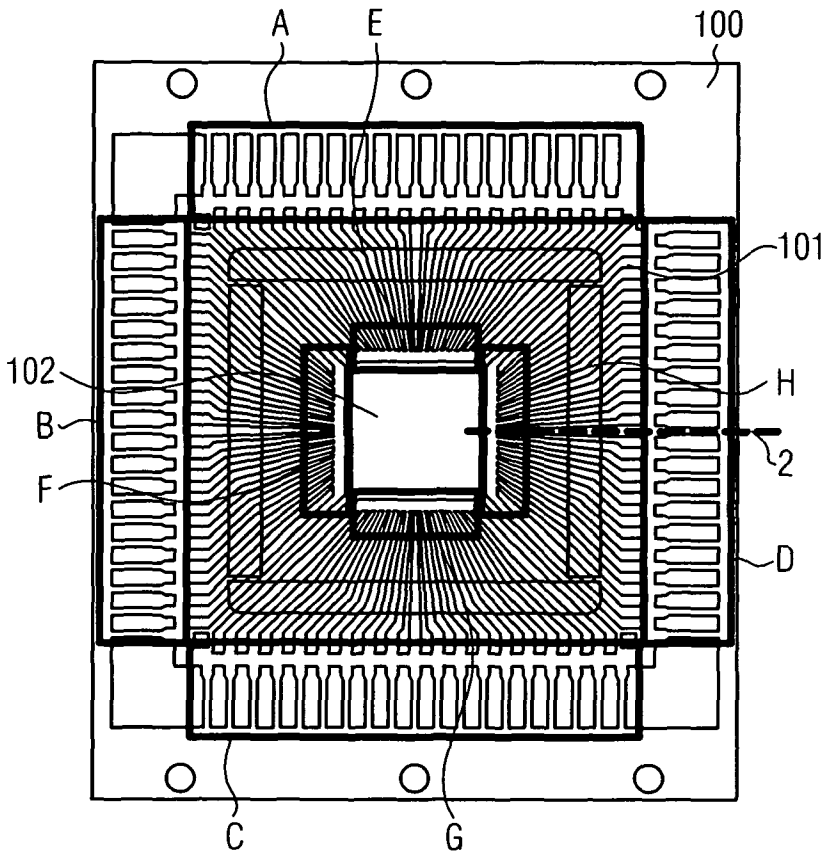


FIG. 1

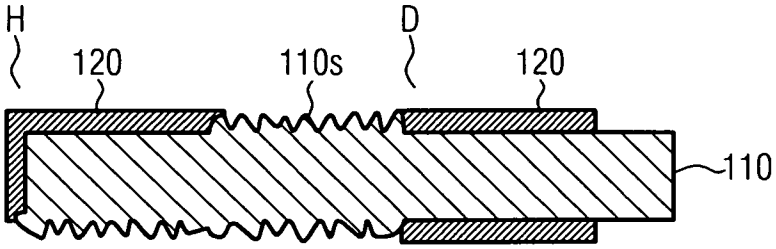


FIG. 2

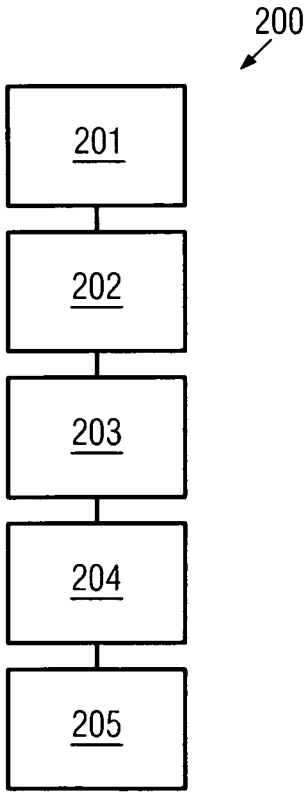
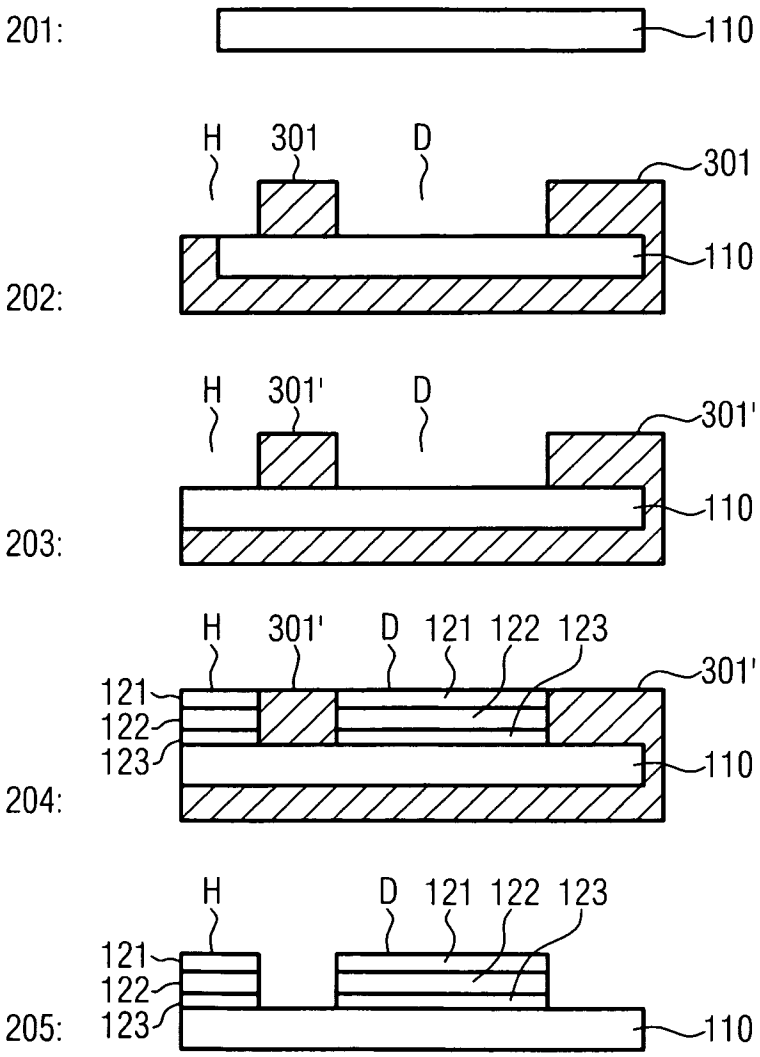


FIG. 3


201:
110
H
301
D
301
110
202:
H
301'
D
301'
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203:
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301'
D
121
122
123
301'
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110
205:

FIG. 4

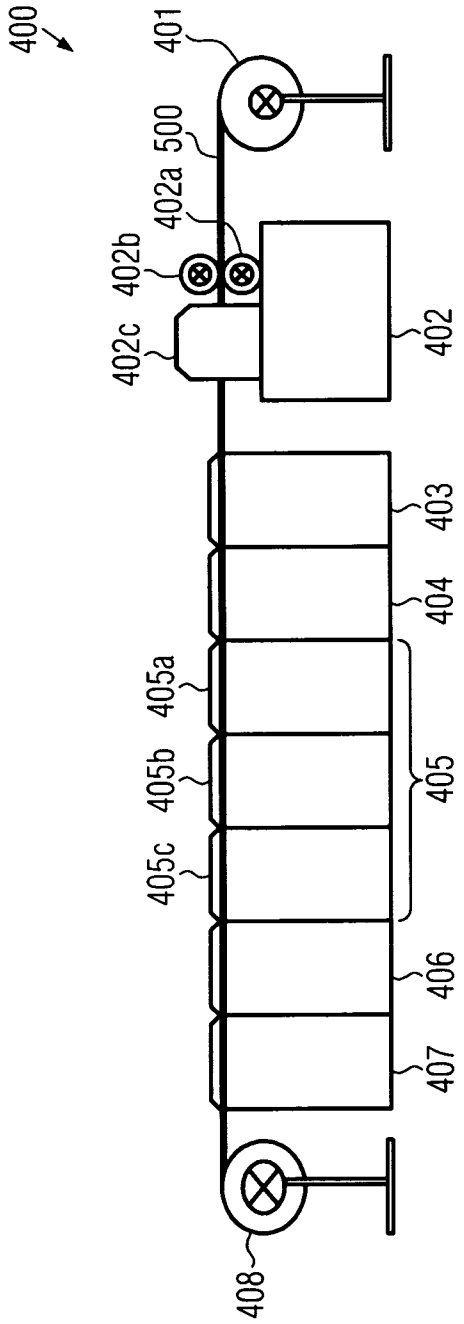
400
401
500
402a
402b
402c
402
403
404
405a
405b
405c
405
406
407
408

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/001928

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/48 B41C1/14
ADD.

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 H05K B41C

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 8 046113 A (DANTANI PLYWOOD CO) 16 February 1996 (1996-02-16)	1,7-13, 15-18
Y	abstract; figures 1-4	2-6,14

Y	JP 60 225453 A (DAINIPPON INK & CHEMICALS) 9 November 1985 (1985-11-09)	2,14
A	abstract; figure 1	1,13

Y	GB 2 333 742 A (LOWE JOHN MICHAEL [GB]) 4 August 1999 (1999-08-04) page 1, lines 13-24 page 9, lines 23-26 page 10, lines 19-29 page 11, lines 19-22	3-6

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 August 2012	08/08/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Zeisler, Peter

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/001928

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 8046113 A	16-02-1996	NONE	
JP 60225453 A	09-11-1985	NONE	
GB 2333742 A	04-08-1999	AU 2290499 A	16-08-1999
		GB 2333742 A	04-08-1999
		WO 9938706 A1	05-08-1999