Title: Process for electroplating a work piece coated with an electrically conducting polymer

The invention refers to a process for electroplating a work piece, which is coated with an electrically conducting or modified polymer. In addition, the invention shows apparatus for carrying out this process.

For the targeted change of the surface, or of the surface structure, of two and three dimensional work pieces, electroplating, even in the case of non-metallic surfaces, is a process which corresponds to the state of the art and which often is used in practice. Thus, for example in the manufacture of a circuit board, metallizing and complete contact formation of the base material is achieved by electroplating. Generally, the base material consists of an insulator where a large portion of the surface, which is to be electroplated, is coated with an electrically conducting or modified, polymer.

However, the deposition of a metallic coating on the large area of an insulator coated with an electrically conducting polymer by electroplating is usually only possible with considerable effort. Due to the fact that even a modified polymer has a high specific electrical resistance compared to a metallic material, the current density on the surface of the work piece to be electroplated is distributed in an uneven manner so that an evenly strong electrical field does not develop. In order to still achieve a continuous metal coat either the current density must be increased or the electroplating time must be extended.

In order to avoid the disadvantages connected with extending the electroplating time, it is known from the current state of the art to increase the current density. However, an excessive current density in the contact area leads to the destruction of the electrically conducting polymer coating. An electroplated metal deposition can then no longer take place, due to the diminished electrical conductivity. In order to avoid such a destruction of the polymer coating, an appropriately low current density must be selected which results in an extension of the electroplating time and the attendant disadvantages.

It is therefore necessary for electroplating a work piece coated with an electrically conducting polymer to determine and to balance the current density

and the electroplating time appropriate to the work piece. In order to obtain a coating without voids it is therefore necessary to consider the balance between excessive current density on the one hand and an excessive electroplating time on the other, whereby the work piece-related parameters are to be determined again. Thus large-scale applications of the processes known from the current state of the art are not satisfactory since either very time-consuming adjustments must be made or a high failure rate results if these adjustments are not made.

In order to avoid the disadvantages mentioned it is therefore the intent of the invention to describe a method for electroplating of a work piece which is coated with an electrically conducting polymer which is independent of the work piece to be electroplated and which permits a shortening of the electroplating time while, at the same time, reducing the current density.

According to the invention this problem is solved by connecting the work piece in the first step of the process to a current source by multiple adjacent contact elements and coating with a continuous, thin metal layer except at the contact locations covered by the contact elements. The contact elements are removed in a second process step, and an unbroken, continuous coat is formed.

It is further proposed by the invention to cover the work piece to be electroplated with a multitude of adjacent contact elements so that a multitude of current-carrying connections between the surface to be electroplated and the current source are formed. This has the advantage that an electrical field is generated even with only a low current density, which is sufficient for electroplating the surface. The electrically conducting polymer coating is connected to the current source so that an almost uniform electrical field is generated covering the entire surface of the work piece to be electroplated.

In the first step of the process described by the invention, after connecting the contact elements to the current source, a thin metal layer is formed on the electrically conducting polymer coating of the work piece to be electroplated. This metal layer is unbroken except for the contact points covered by the contact elements. The contact elements are laid out on the surface to be electroplated in such a manner that the metal layer deposited in the first step of the process extends over the entire surface and forms a continuous metal coat. Due to the multitude of the contact elements used, the build-up of the metal coat requires

only a relatively short electroplating time. It is of advantage that despite the reduction of the current density the electroplating time does not increase. To the contrary, the process described by the invention presents the possibility to also reduce the electroplating time despite the reduced current density. The disadvantages of the processes known from the current state of the art represented by a destruction of the polymer coating, due to an excess of current density or due to an excess of electroplating time can be entirely avoided by the use of the process described by the invention.

After the deposition of the continuous metallic coat, except the points covered by the contact elements, these are removed in the second process step, and the surface area to be electroplated is charged with current through the metal coat formed in the first process step. A metal deposit now also forms at the contact points covered by the contact elements during the first process step, so that a unbroken metal coat forms over the entire surface of the work piece to be electroplated. During this second electroplating step also only relatively low current densities as well as short electroplating times are required since the metal coat formed in the first process step covers the surface area, and thus a generally homogeneous electrical field is built also with low current density. In addition, in contrast to a polymer coat, the metallic coat represents a good electrical conductor with a low specific resistance.

The second process step intended for the formation of an unbrokenly continuous metal coat can be carried out in accordance with the invention in such a manner that the contact points not yet covered after the completion of the first step are provided with a metal coating, so that in this manner the contact points still remaining open are "closed", and an unbroken metal coat is formed in the second process step. The second process step can also be carried out in such a manner that the metal coat formed in the first process step keeps growing so that an unbroken metal coat is formed which also covers the contact points. The second process step can also be carried out using a different electrolyte composition, for example. When carrying out this process, it is important that the connection of the work piece to be coated is by multiple adjoining contact elements so that a generally homogeneous electrical field is built over the entire surface. The contact points covered up by the contact elements of the surface to

be coated can then be closed by the formation of an unbroken metal coating in a second process step.

With the process described in the invention, it is possible for the first time to provide a two or three dimensional work piece with an electrically conducting polymer coat with a metal coating by electroplating, whereby in spite of reduced current density only a relatively short electroplating time is required. The disadvantages of the known processes from the current state of the art which result in the destruction of the polymer coat due to excessive current density and due to excessive electroplating time can therefore be avoided. An electroplating process conducted as described in the invention permits the mass production of electroplated work pieces since with regard to the current density to be set and the electroplating time to be selected, the greatest independence from the work piece to be electroplated is achieved, and also a costly readjustment of these process parameters prior to the beginning of each new electroplating process is not required.

In accordance with one characteristic of the invention, the individual contact elements on the surface to be electroplated are placed lattice-like next to each other. In this manner it is achieved that both in the first process step in which the surface to be coated is connected to the current source over the contact elements and also in the second process step when the current supply takes place over the metal coating formed in the first process step an extensive, evenly formed electrical field extends over the entire surface area to be electroplated. In addition, it is achieved that the metal coat to be formed in the first process step by itself constitutes a continuous electrical conductor. It is therefore suggested that it is especially advantageous if neighboring contact elements are laid out equidistant.

In accordance with another characteristic of the invention, a contact element carrier is used for the contact element layout, which comprises several contact elements. On the one hand, a quick placement of the contact elements on the surface to be electroplated is achieved in this manner, on the other hand, the use of a contact element carrier permits extensive automation of the process described in the invention. The contact element carrier preferably is designed in such a manner that it comprises multiple adjoining contact elements which can be

moved from their relative position for adjustment purposes, whereby adjustment of the contact elements relative to each other as well as to the contact element carrier itself is possible. Depending on the work piece to be electroplated, adjustment of the contact elements is possible so that it can be ensured that all contact elements to be placed on the surface of the work piece to be electroplated actually establish an electrical connection between the work piece to be electroplated and the current source. In this manner, it can be avoided that voids appear in the metal coating to be formed.

In accordance with a first alternative, a frame with mounted contact elements is used as a contact element carrier. Such a frame-like contact element carrier is especially suitable for electroplating of 2-dimensional work pieces such as, for example, circuit boards. As suggested by the invention, such a frame is rectangular in shape while other geometric shapes are conceivable, depending on the type of application. Multiple contact elements are mounted on the frame which are placed either on all or on individual components forming the frame. For the connection of the surface to be electroplated to the current source, this is contacted by the elements of the frame-shaped contact element carrier. In this connection, in accordance with a further characteristic of the invention, for large area coverage, several frames can be placed next to each other or on either side of the work piece to be electroplated. It is especially attractive in the case of circuit boards, to metal-coat the basic raw circuit board on both sides in the course of one process step.

In accordance with a further characteristic of the invention, a fixture with multiple contact elements is used as contract element carrier. A fixture of this type especially serves the connection of a 3-dimensional work piece. This is inserted into a fixture designed for this purpose and connected to the current source over the contact elements attached to the fixture. In this manner it is made possible to unbrokenly electroplate even a geometrically complex work piece in one process step. It is self-evident, of course, that in addition to the design of the contact element carrier as a frame or as a fixture other forms are conceivable. The deciding factor is that the surface of the work piece to be electroplated can be covered area-wide by the contact element carrier with multiple contact elements.

In accordance with a further characteristic of the invention, the contact elements are designed to be movable in their relative position on the one hand to each other, as well as to the contact element carrier on the other hand; and that they can be adjusted for contact with the work piece to be electroplated for connection to the current source, depending on the work piece geometry. Thus, it can be ensured that by means of the process described by the invention not only regularly shaped work piece surfaces but also irregularly shaped, complex geometric forms can be covered over their entire area by contact elements, and the work piece to be electroplated can be connected to the current source.

In accordance with a further characteristic of the invention, a metallic grate is used as the contact element carrier. The metallic grate is especially suited to horizontal applications in continuous processing facilities. This metallic grate constitutes a complete electrical conductor so that its placement on the surface to be electroplated leads to the build-up of a general, homogeneous electrical field. Thus, within a relatively short time, and using only a low current density, a metallic coat can be formed which basically constitutes a negative of the grid. In other words, the areas of the surface to be electroplated not covered by the grid are covered with a metal layer. In a second step of the process, the grid can then be removed and a closed metal coating formed on the surface. In accordance with an advantageous characteristic, the surface to be electroplated is contacted by the grid, and the work piece together with the grid is fed through the electrolyte. Thus, the grid simultaneously also serves as a conveyor. In this manner, given short cycle rates and ease to automate, and above all reproducible, surfaces of work pieces can be electroplated in accordance with the process described by the invention. In order to ensure that the metal grate placed on the work piece to be electroplated can be removed without destroying the underlying polymer coat after the deposition of the first metal coating, it is another characteristic of the invention that counter anodes are supplied by which the metal deposited from the metallic grid is loosened from the work piece.

In accordance with a further characteristic of the invention, the thickness of the metal coat produced by the process, which is the subject of the invention, can be specified. This can be adjusted, on the one hand by the dwell time of the

work piece in the electrolyte, and by the connected current density on the other. In any case, it is possible to build a metal coat of the required thickness adapted to the later demands on the finished work piece.

Additional details, characteristics and advantages of the invention are discussed in the following descriptions of the enclosed drawings:

Fig. 1 is a schematic of the first step of the process described by the invention for the manufacture of a circuit board in the vertical process.

Fig. 2 is a schematic of the second step of the process described by the invention for the manufacture of a circuit board in the vertical process.

Fig. 3 is a schematic of a grate serving as a contact element carrier.

Fig. 4 is a schematic of the first step of the process described by the invention for the manufacture of a circuit board in the horizontal process.

Fig. 5 is a schematic section of a contact element in accordance with a first application design.

Fig. 6 is a schematic section of a contact element in accordance with a second application design.

Fig. 1 shows the manufacture of a circuit board 1 in accordance with the process described in the invention. Here, the first step of the process is shown. In electrolyte 2, generally perpendicular to the electrolyte surface 3, a base body 4 made of an insulator and coated with an electrically conducting or modified polymer layer is inserted. Due to the fact that the base body 4 is moved generally perpendicular to the electrolyte surface 3, this process may also be referred to as a vertical process.

The base body 4 is connected to the current source 8 over multiple contact elements 5. This is achieved by a branching electric wire 9. As can be seen in Fig. 1 schematically, all contact elements 5 are placed onto the base body 4 which is to be electroplated and make electrical contact with the current source 8 by means of the contact element carriers 7. For example, the figure shows three frame-shaped contact element carriers 7 with five contact elements 5 attached to each. The contact elements 5 are fixed to each of the contact element carriers in such a manner that they are movable both relative to each other and relative to the contact element carrier 7, so that individual adjustment of the contact elements 5 can be made with reference to the size or geometric shape of the base body 4

which is to be electroplated. After applying the current, based on the multiple contact elements 5 used, a nearly homogeneous electrical field is built up which extends over the entire surface of the base body 4 to be electroplated. As a result of the build-up of the even electric field extending over a wide area, an unbroken, thin metal coat 10 forms within a short time at a relatively low current density except at the contact points 6, covered by the contact elements 5. By the use of multiple contact elements 5 electroplating can occur within a short electroplating time, despite a low current density.

Fig. 2 shows the second process step as described in the invention. After the build-up of the metal coat 10 with the exception of the contact points 6 covered by the contact elements 5, the contact elements are removed and an unbroken metal coat is formed. For this, the metal coat produced in the first process step is connected to the current source 8 by means of the electric wire 9. In this manner, an also nearly homogeneous electrical field is built up which leads to the still void spots in the metal coat 10 being closed by metal deposition, and an unbroken metal coat is created. After the build-up of the specified layer thickness of the metal coat, the base body 4 is again removed from the electrolyte 2.

Fig. 3 shows an alternative version of a metallic grate 11 which serves as an area contact element and which is provided with insulation except for the contact points. In the first process step the work piece to be electroplated is laid onto the grate 11 with the surface to be electroplated toward the grate and fed through the electrolyte 2 in the horizontal process. This is shown schematically in Fig. 4. This can be viewed as grate 11 forming an endless band which, at the same time, serves as the conveyor. By means of reversing rolls 12 the grate 11 is moved by a drive unit 13 in the transport direction 14. The grate 11 is connected to a current source 8 by sliding contacts 15, for example. For the manufacture, for example of circuit boards, the base bodies 4 are laid on the grate 11 at the loading station 16. The loading station 16 is located outside the electrolyte tank 17. The base bodies 4 laying on the grate 11 are transported in direction 14 and inserted into electrolyte tank 17 and immersed in the electrolyte 2. Due to the fact that the grate 11 generally runs parallel to the electrolyte surface 3 this process is also referred to as the horizontal process, in contrast to the previously mentioned vertical process. As a result of the wide area coverage of the surface of the base

body 4 to be electroplated, only a relatively weak current density and a short electroplating time are required for the formation of a first metallic coat. After the build-up of this metal coat, the base bodies 4 are removed from the electrolyte tank 17 in the direction 14 and transported to the unloading station 18. There, the base bodies 4 are removed from the grate 11. In order to avoid permanent electroplating of the contact points, the metal deposited there can be dissolved by means of the counter anode 19. Subsequent to the completion of the first process step and the build-up of metal coats in accordance with Fig. 4, there follows in a manner similar to the vertical process already described above, the build-up of the unbroken metal covering.

Fig. 5 and 6 each show two alternatives of a contact element 5 located on a contact element carrier 7. The contact elements shown in Fig. 5 and 6 differ due to their relative movability in the lifting direction 20. This is achieved by a suitable spring element. Individually, the contact elements are designed as follows: The current-carrying contact pin 21 is movable radially relative to the base body 4 (lifting direction 20). The contact pin 21 is surrounded by insulation 22 and attached to the contact element carrier 7 by a threaded connector 23. This design has the advantage of fitting the contact element 5 also to a non-level surface of the base body 4. By this method it is ensured that multiple contact elements 5 contact the base body 4, and thus an electrical connection is established between the base body 4 and the current source 6.

Reference key list

1	Circuit board
2	Electrolyte
3	Electrolyte surface
4	Base body
5	Contact element
6	Contact point
7	Contact element carrier
8	Current source
9	Electric wire
10	Metal coating
11	Grate
12	Reversing rolls
13	Drive unit
14	Transport device
15	Sliding contact
16	Loading station
17	Electrolyte tank
18	removal station
19	Counter anode
20	Stroke direction
21	Contact pin
22	Insulation
23	Connecting unit

Claims

1. A process for electroplating a work piece coated with an electrically conducting or modified polymer characterized by the work piece, in a first process step, being connected by multiple adjoining contact elements to a current source and coated with a thin metal layer, except at the contact points covered by the contact elements and subsequently, in a second process step, the contact elements being removed an unbroken metal coat is formed.

2. A process in accordance with claim 1, characterized by the individual contact elements being arranged next to each other, lattice-like on the surface of the work piece to be electroplated.

3. A process in accordance with claims 1 and 2, characterized by adjoining contact elements being located equidistant to each other.

4. A process in accordance with claim 1 to 3, characterized by a contact element carrier with multiple contact elements for the arrangement of the contact elements being used.

5. A process in accordance with claim 4, characterized by a frame with contact elements attached being used as the contact element carrier.

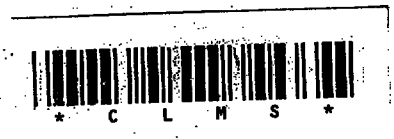
6. A process in accordance with claim 5, characterized by several frames being used next to each other and/or on both sides of the work piece to be electroplated for large area coverage of the surface to be electroplated.

7. A process in accordance with claim 4, characterized by a rack with several contact elements attached being used as a contact element carrier.

8. A process in accordance with claim 1 to 7, characterized by the contact elements being adjustable in their relative position to the contact element carrier and located for connecting the work piece to be electroplated to the current source, depending on the work piece geometry.

9. A process in accordance with claim 4, characterized by a metallic grate being used as the contact element carrier.

10. A process in accordance with claim 9, characterized by the grate being placed on the surface of the work piece to be electroplated, and that the work piece is guided through the electrolyte together with the grate.



11. A process in accordance with claim 10, characterized by the metal deposited on the metallic contact points being dissolved by means of counter anodes.

12. A process in accordance with one of the foregoing claims, characterized by the metal coat being formed in a thickness, which can be selected.

13. A fixture for carrying out the process in accordance with one of the claims 1 to 12, characterized by at least one contact element carrier with multiple adjoining contact elements being provided for connection of the work piece to be galvanized with a current source.

14. A fixture in accordance with claim 13, characterized by the individual contact elements being installed on the contact element carrier in such a manner that their position on the contact element carrier is adjustable.

15. A fixture in accordance with claim 13 and 14, characterized by the contact element carrier being designed as a frame or a rack.

16. A fixture in accordance with claim 13 and 14, characterized by the contact element carrier being a metallic grate onto which the work piece to be electroplated may be placed.

17. A fixture in accordance with claim 16, characterized by the metal grate forming and endless band.

18. A fixture in accordance with claim 17, characterized by the grate simultaneously serving as a work piece conveyor.

19. A fixture in accordance with claim 16 to 18, characterized by counter anodes being provided in order to avoid galvanizing of the contact points.