

“as originally filed”

Device and Method for Electrolytic Coating

5 Description

The invention relates to a device for the electrolytic coating of at least one electrically conductive substrate or a structured or full-surface electrically conductive surface on a nonconductive substrate, which comprises at least one bath, one anode and one cathode, the bath containing an electrolyte solution
10 containing at least one metal salt, from which metal ions are deposited on electrically conductive surfaces of the substrate to form a metal layer.

The invention furthermore relates to a method for the electrolytic coating of at least one substrate, which is carried out in a device designed according to the
15 invention.

Electrolytic coating methods are used, for example, in order to coat electrically conductive substrates or structured or full-surface electrically conductive surfaces on a nonconductive substrate. For example, these methods can produce
20 conductor tracks on printed circuit boards, RFID antennas, flat cables, thin metal foils, conductor tracks on solar cells, and can electrolytically coat other products such as two- or three-dimensional objects, for example shaped plastic parts.

25 DE-B 103 42 512 discloses a device and a method for the electrolytic treatment of electrically conductive structures electrically insulated from one another on surfaces of a strip-shaped object to be treated. Here, the object to be treated is transported on a transport path and continuously in a transport direction, the object to be treated being contacted with a contacting electrode arranged outside
30 an electrolysis region so that a negative voltage is applied to the electrically conductive structures. In the electrolysis region, metal ions from the treatment liquid then deposit on the electrically conductive structures to form a metal layer. Since metal is deposited on the electrically conductive structures only so long as they are contacted by the contact electrode, it is only possible to coat structures
35 which are so largely dimensioned that the electrically conductive structure to be coated lies in the electrolysis region while being simultaneously contacted outside the electrolysis region.

A galvanizing apparatus in which the contacting unit is arranged in the electrolyte bath is disclosed, for example, in DE-A 102 34 705. The galvanizing apparatus described here is suitable for coating structures arranged on a strip-shaped support, which are already conductively formed. The contacting is in this case
5 carried out via rolls which are in contact with the conductively formed structures. Since the rolls lie in the electrolyte bath, metal from the electrolyte bath likewise deposits on them. In order to be able to remove the metal again, the rolls are constructed from individual segments which are connected cathodically so long as they are in contact with the structures to be coated, and connected anodically
10 when there is no contact between the rolls and the electrically conductive structure. A disadvantage of this arrangement, however, is that a voltage is applied only for a short time on structures which are short as seen in the transport direction, while a voltage is applied over a substantially longer period of time on structures which are long, likewise as seen in the transport direction. The layer
15 which is deposited on long structures is therefore substantially larger than the layer which is deposited on short structures.

A disadvantage of the methods known from the prior art is that they cannot be used to coat structures which are very short - especially as seen in the transport
20 direction of the substrate. Another disadvantage is that many rolls connected in series are required in order to produce sufficiently long contact times, so that a very long device is needed.

It is an object of the invention to provide a device which ensures a sufficiently long
25 contact time even for short structures, so that short structures can also be provided with a sufficiently thick metal layer.

The object is achieved by a device for the electrolytic coating of at least one electrically conductive substrate or a structured or full-surface electrically
30 conductive surface on a nonconductive substrate, which comprises at least one bath, one anode and one cathode, the bath containing an electrolyte solution containing at least one metal salt. From the electrolyte solution, metal ions are deposited on electrically conductive surfaces of the substrate to form a metal layer. To this end, the at least one cathode is brought in contact with the
35 substrate's surface to be coated while the substrate is transported through the bath. According to the invention, the cathode comprises at least one band having at least one electrically conductive section, which is guided around at least two

rotatable shafts. The shafts are configured with a suitable cross section matched to the respective substrate. The shafts are preferably designed cylindrically and may, for example, be provided with grooves in which the at least one band runs. For electrical contacting of the band, at least one of the shafts is preferably
5 connected cathodically, the shaft being configured so that the current is transmitted from the surface of the shaft to the band. When the shafts are provided with grooves in which are the at least one band runs, the substrate can be contacted simultaneously via the shafts and the band. Nevertheless, it is also possible for only the grooves to be electrically conductive and for the regions of
10 the shafts between the grooves to be made of an insulating material, so as to prevent the substrate from being electrically contacted via the shafts as well. The current supply of the shafts takes place via sliprings, for example, although it is also possible to use any other suitable device with which current can be transmitted to rotating shafts.

15 Since the cathode comprises at least one band having at least one electrically conductive section, it is possible even for substrates with short electrically conductive structures, especially as seen in the transport direction of the substrate, to be provided with a sufficiently thick coating. This is possible since
20 owing to the configuration of the cathode as a band, according to the invention, even short electrically conductive structures stay in contact with the cathode for a longer time than is the case in the methods known from the prior art.

So that is also possible to coat regions of the electrically conductive structure on
25 which the cathode configured as a band rests for contacting, in a preferred embodiment at least two bands are arranged offset in series. The arrangement is preferably such that the second band, arranged offset behind the first band, contacts the electrically conductive structure in the region on which the metal was deposited when contacting with the first band. In order to achieve a larger
30 thickness of the coating, preferably more than two bands are connected in series.

In one embodiment, respectively successive bands arranged offset are guided via at least one common shaft. When the bands are respectively guided via two shafts in this case, as seen in the transport direction of the substrate, the rear
35 shaft of the first band is simultaneously the front shaft of the second band. The advantage of this arrangement is that it is possible to economize on shafts and the bath can be kept shorter. Besides the arrangement in which respectively

successive bands arranged offset are guided via at least one common shaft, it is also possible to guide the successively arranged bands via respectively independent shafts. In such an arrangement, it is advantageous for the shafts to be configured so that they can be raised from the substrate. During the coating process, i.e. so long as the shafts and the bands are connected cathodically, metal also deposits on the bands and the shafts. In order to remove this metal again, it is necessary to connect the shafts and the bands anodically. When the bands are respectively arranged independently on shafts, the respectively individual bands together with their shafts can be raised from the substrate and connected anodically, while bands preceding or following the raised bands simultaneously contact the substrate and the electrically conductive structures lying on it, so that the removal of the deposited metal from the bands and shafts can take place during continuous operation. When the shafts cannot be raised, or when only one group of bands connected offset in series is provided, in which respectively successive bands arranged offset are guided via at least one common shaft, the metal deposited on the bands and shafts can only be removed during production pauses.

In a further embodiment, the at least one band has a network structure. The advantage of the network structure is that only small regions of the electrically conductive structures to be coated on the substrate are respectively covered by the band. The coating takes place in the holes of the network. So that it is also possible to coat the electrically conductive structures in the regions on which the network rests, even for the case in which the bands are designed in the form of a network structure it is advantageous to arrange at least two bands respectively offset in series. It is also possible to connect two bands designed as networks directly in series, the networks then respectively having different mesh widths and/or different mesh shapes so that regions on which the front network rests can also be coated. Furthermore, it is also possible to provide one band configured as a network, the band having regions with a different mesh width and/or a different mesh shape. Bands with individual holes formed in them are also to be understood as a network in the context of the present invention.

The advantage of a band designed in the form of a network is that the network can extend over the entire width of the shafts. It is not necessary for a plurality of narrow bands designed in the form of networks to be arranged next to one another.

So that electrically conductive structures which are as small as possible, i.e. even structures less than 500 μm as are required in printed circuit board fabrication, can also be coated on the substrate, the width of the individual bands is selected to be as narrow as possible when they are not designed in the form of a network. The width of the bands in this case depends on the fabrication possibilities. The narrower the bands can be formed, the smaller are the conductive structures which can be coated. An advantage of narrow bands with a small distance between them is that the contacting probability of extremely small structures is therefore greater than with a smaller number of wide bands. Since the contact surface of the bands impedes the deposition by covering the structures directly under the band, it is advantageous for this covering effect to be minimized by narrow bands. At the same time, the electrolyte throughput over the surfaces to be metallized is more uniform owing to a multiplicity of smaller surface accesses than with few surface accesses, as there are with a small number of wide bands.

The number of bands arranged next to one another depends on the width of the substrate. When the substrate to be coated is wider, commensurately more bands must be arranged next to one another. Here, care should be taken that a free gap respectively remains between the bands, in which the metal can be deposited on the electrically conductive substrate or the structured or full-surface electrically conductive surface of the substrate. When respectively at least two bands are arranged offset in series, the gap between two bands arranged next to each other is preferably as wide as the band arranged offset behind. Since in the case of a band configured in the form of a network, the coating takes place on the substrate's positions exposed by the individual holes of the network, it is not absolutely necessary here to arrange a plurality of narrow bands in network form next to one another. In this case, it may be sufficient to use one band which extends over the entire width of the substrate.

In a further embodiment, the at least one band alternately comprises conductive sections and nonconductive sections. In this case it is possible for the band to be additionally guided around at least one anodically connected shaft, although care should be taken that the length of the conductive sections is less than the distance between a cathodically connected shaft and a neighboring anodically connected shaft. In this way, regions of the band which are in contact with the substrate to be coated are connected cathodically, and regions of the band which are not in

contact with the substrate are connected anodically. The advantage of this connection is that metal which deposits on the band during the cathodic connection of the band is removed again during the anodic connection. In order to remove all metal which has deposited on the band while it was connected

5 cathodically, the anodically connected region is preferably longer than or at least equally long as the cathodically connected region. This may be achieved on the one hand in that the anodically connected shaft has a greater diameter than the cathodically connected shafts, and on the other hand, with an equal or smaller diameter of the anodically connected shafts, it is possible to provide at least as

10 many of them as cathodically connected shafts, the spacing of the cathodically connected shafts and the spacing of the anodically connected shafts preferably being of equal size.

In order to achieve uninterrupted cathodic connection of the band while it contacts

15 the electrically conductive surfaces of the substrate with the electrically conductive structures lying on them, the length of the conductive sections is preferably greater than or equal to the distance between two neighboring cathodically connected shafts. Coating then takes place on the electrically conductive structure of the substrate from the first contact of the electrically conductive structure with

20 the cathodically connected section of the band until the time at which the contact of the cathodically connected section of the band with the electrically conductive structure on the substrate is ended.

As bands with alternately conductive and nonconductive sections, for example, it

25 is possible to use linked bands in which the individual links are fastened to one another, for example by brackets. A corresponding number of electrically conductive links are mounted in succession according to the required length of the conductive sections. In order to produce an electrically nonconductive section, at least one nonconductive link is inserted between two electrically conductive links.

30 Besides the structure as a linked chain, it is also possible to provide at least one electrically nonconductive flexible band as a support, which comprises electrically conductive sections fitted electrically insulated from one another at predetermined distances. A suitable conductive material here is, for example, wire or foils which are wound around the support or else flexible or rigid foils which, for example,

35 may also be provided in the form of a network or have holes which are connected to the support. The connection to the support may, for example, be carried out using adhesives. Besides the embodiment with a single support per band, for

example, it is also possible to arrange a plurality of supports next to one another, which are connected together by common conductive sections. A gap is preferably formed between the individual supports in this case. Furthermore, it is also possible for the supports to contain holes or have a structure in the form of a network.

When the band has a network structure, for example in which an electrically conductive network is connected to an electrically nonconductive network in order to form the electrically conductive sections and electrically nonconductive sections, the electrically conductive sections in the form of a network may be connected to the meshes of a nonconductive section, for example with the aid of a wire which is guided through the individual meshes of the network structure.

Besides the embodiments described here, the band may nevertheless also have any other structure by which conductive and nonconductive sections can be produced in alternation.

In a further embodiment, the electrolytic coating device furthermore comprises a device with which the substrate can be rotated. The rotation axis of the device, with which the substrate can be rotated, is arranged perpendicularly to the substrate's surface to be coated when electrically conductive structures which are initially wide and short as seen in the transport direction of the substrate are intended to be aligned by the rotation so that they are narrow and long as seen in the transport direction after the rotation. The rotation compensates for different coating times which are due to the fact that coating already takes place upon the first contact of the electrically conductive structure with the cathodically connected band.

In order to coat on a plurality of sides of the substrate it may preferably be rotated in the device, with which the substrate can be rotated, so that after the rotation the surface to be coated first points in the direction of the coating.

In order to coat both the upper side and the lower side of the substrate simultaneously, in a further embodiment at least two bands are respectively arranged so that the substrate to be coated is guided through between them and the bands respectively contact the upper side and the lower side of the substrate.

In order to coat rigid structures, the structure of the electrolytic coating device is preferably such that the transport plane of the substrate serves as a mirror plane. When the intention is to coat foils whose length exceeds the length of the bath – so-called endless foils which are first unwound from a roll, guided through the electrolytic coating device and then wound up again – they may for example also be guided through the bath in a zigzag shape or in the form of a meander around a plurality of electrolytic coating devices according to the invention, which for example may then also be arranged above one another or next to one another. The devices may respectively be aligned at any desired angle in the bath. When the electrolytic coating devices are arranged above one another, it is also possible to coat the foils simultaneously on the upper side and the lower side by guiding them respectively through between two devices which contact the foil on the upper and lower sides and then deviating them around one of the devices after passing through, so that they can then be guided through between it and a further device arranged above or below the device.

With the device according to the invention and the method according to the invention, it is furthermore possible to coat through-holes contained in the substrate, for instance bores or slots, or even indentations such as blind holes. In the case of through-holes of shallow depth, the coating is carried out in that the metal layers deposited on the upper side and the lower side grow together in the hole. In holes which are too deep for the metal layers to grow together, a conductive hole wall is at least partially provided which is coated by the method according to the invention. In this way, it is then also possible to coat the entire wall of a hole. If not all of the hole wall is electrically conductive, here again the entire hole wall is coated by the metal layers growing together.

So that the metal which deposits on the cathodically connected shafts and/or bands can also be removed again during operation of the electrolytic coating device, the shafts in a preferred embodiment can be connected both anodically and cathodically and can be lowered onto the substrate or raised from the substrate. While these shafts are raised from the substrate and are not in contact with the substrate, they can be connected anodically. While the shafts are connected anodically, the metal deposited thereon is removed again from them. Simultaneously, the at least one band running around the shaft is also connected anodically so that the metal deposited thereon is also removed from it. The shafts which are in contact with the substrate via the at least one band are connected

cathodically.

In a further embodiment, the shafts may also contain a plurality of electrically conductive regions, at least one of which is connected anodically and at least one
5 other is connected cathodically. In this case the band running around is likewise connected cathodically in the cathodically connected region of the shaft, so that coating of the electrically conductive substrate or the structured or full-surface electrically conductive surface of the substrate takes place, while the undesired material previously deposited in the anodic region is removed again from the shaft
10 and/or the at least one band. In this case, it is necessary for the band to have sections electrically insulated from one another, which are arranged on the shafts so that an electrically conductive region of the band does not simultaneously touch an anodically connected region and a cathodically connected region on the shaft, in order to avoid a short circuit.

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Other cleaning variants are also possible besides cleaning by reversing the polarity of the shafts, for example chemical or mechanical cleaning.

The electrically conductive sections of the at least one band and the shaft
20 surfaces, or the shaft regions which are in contact with the at least one band, are preferably made of an electrically conductive material which does not pass into the electrolyte solution during operation of the device. Suitable materials for making the conductive sections of the band and the shaft surfaces, or the shaft regions which are in contact with the at least one band, are for example metals,
25 graphite, conductive polymers such as polythiophenes or metal/plastic composite materials. Stainless steel and/or titanium are preferred materials.

With different poling of the shafts, on the one hand, the anodically connected shafts may be used as anodes, and on the other hand it is possible to provide
30 additional anodes in the bath. When only cathodically connected shafts and disks are provided, it is necessary to arrange additional anodes in the bath. The anodes are then preferably arranged as close as possible to the structure to be coated. For example, the anodes may respectively be arranged between two cathodically connected shafts. On the one hand any material known to the person skilled in the
35 art for insoluble anodes is suitable as a material for the anodes. Stainless steel, graphite, platinum, titanium or metal/plastic composite materials, for example, are preferred here. On the other hand, soluble anodes may also be provided. These

then preferably contain the metal which is electrolytically deposited on the electrically conductive structures. The anodes may then assume any desired shape known to the person skilled in the art. For example, it is possible to use flat rods as anodes which are at a minimal distance from the substrate surface during operation of the device, and which can be retracted from the device in the direction of the shaft axes for a position change of the shafts. It is also possible to use flat metal as anodes, which can be folded by 90° vertically upward or downward between the roll displacements. A further possibility is to provide resilient wires as anodes, for example spiral wires, which can be drawn upward or downward out of the device and inserted into it from winding/unwinding devices.

The electrolytic coating device can be used for any conventional metal coating. The composition of the electrolyte solution, which is used for the coating, in this case depends on the metal with which the electrically conductive structures on the substrate are intended to be coated. Conventional metals which are deposited on electrically conductive surfaces by electrolytic coating are, for example, gold, nickel, palladium, platinum, silver, tin, copper or chromium.

Suitable electrolyte solutions, which can be used for the electrolytic coating of electrically conductive structures, are known to the person skilled in the art for example from Werner Jillek, Gustl Keller, Handbuch der Leiterplattentechnik [handbook of printed circuit technology], Eugen G. Leuze Verlag, 2003, volume 4, pages 332 to 352.

In order to electrolytically coat the electrically conductive structures on the substrate, it is first delivered to the bath of electrolyte solution. The substrate is then transported through the bath, the at least one band of the cathode resting on the substrate and thus contacting the electrically conductive structures, the band preferably being moved with a circulation speed which corresponds to the speed with which the substrate is guided through the bath. The substrate may be transported through the bath using a transport device, for example, as is known to the person skilled in the art. It is nevertheless also possible to arrange the coating device so that the substrate rests on the at least one cathodically connected band and is transported through the bath by the movement of the band. In particular, it is advantageous to transport the substrate through the bath with the at least one band of the coating device functioning as a transport device whenever the substrate is intended to be coated on the upper side and the lower side. In this

case, the substrate rests on one device while being pressed onto the device on which it rests by the other device. The substrate is then transported through the device by the movement of the bands.

5 Besides the bands, for example, it is nevertheless also possible for at least one further transport roll, which preferably consists of an electrically insulating material, to transport the substrate through the bath. A combination of at least one band with at least one additional transport roll is likewise possible. The number of transport rolls required depends on the size of the substrate to be coated. The
10 spacing of the transport rolls must be selected so that at least one transport roll is always in contact with the substrate, unless the transport takes place using the bands. For the electrolytic coating of endless substrates, the transport may also be carried out using the winding and unwinding unit which is preferably arranged outside the bath.

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When the shafts are provided with grooves in which at least one band runs, the transport of the substrate by the shafts and/or by the band takes place when they are driven.

20 So that the substrate is not on the one hand raised from the electrolytic coating device and/or on the other hand pressed against the device from below, and good contact of the substrate with the cathodically connected regions is thereby simultaneously ensured, at least one pressure roll or pressure band with which the substrate is pressed against the cathodically connected regions is preferably
25 provided for one-sided coating.

A good contact between the cathodically connected band and the substrate to be coated may also be achieved by pressing the band onto the substrate via the weight of the shafts around which it runs. It is also possible to produce an
30 additional application pressure by pressing the band against the substrate by spring mounting of the shafts.

The shafts are preferably driven outside the bath. In a preferred embodiment, all the shafts are driven. It is nevertheless also possible to drive only some of the
35 shafts. When a transport device independent of the cathodes is provided, the bands may be driven by the substrate lying in contact with them, no shaft around which the band runs being provided with its own drive. It is nevertheless also

possible for the band to be additionally driven by the at least one shaft around which it runs. So that a uniform speed of all the bands is achieved, it is preferable for the shafts to be driven via a common drive unit. The drive unit is preferably an electric motor. The shafts are preferably connected to the drive unit via a chain or belt transmission. It is nevertheless also possible to provide the shafts respectively with gearwheels which engage in one another and via which the shafts are driven. Besides the possibilities described here, it is also possible to use any other suitable drive known to the person skilled in the art for driving the shafts.

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In a preferred embodiment, the at least one band is supplied with voltage via the shaft around which it runs. The shafts may in this case be electrically conductive over the full surface or partially on the surface. It is nevertheless also possible to make the shafts from an insulating material and provide contact means which, for example, are arranged between individual shafts. Such contact means may, for example, be brushes which are in contact with the electrically conductive sections of the band. Preferably, however, the current supply takes place via the shafts. The voltage supply of the shafts in this case preferably takes place outside the bath. Suitable means for transmitting current to the shafts are, for example, sliprings which are arranged on the shafts. For bands whose electrically conductive section is at least as long as the contact surface on the substrate, it is also possible to make only some shafts electrically conductive and the remaining shafts electrically insulating. In this case, it is also possible to connect one shaft anodically and one shaft cathodically, while the other shafts are insulated. In this embodiment, care must be taken that the distance between the cathodically connected shaft and the anodically connected shaft is greater than the length of the electrically conductive region of the band.

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In order to demetallize the cathodically connected shafts and optionally bands, i.e. remove the metal deposited on them, they are either connected anodically during production pauses or raised from the substrate and then connected anodically. It is necessary that no contact of the shafts with the structures to be coated should occur while they are being demetallized. Otherwise, the structures to be coated would likewise be anodically connected anodically and the material already deposited on them would be removed again. When the at least one band, which forms the cathode, is constructed segmentally from conductive and nonconductive sections which run around anodically and cathodically connected shafts, in a

preferred method variant the cathodically connected shafts are raised from the substrate for demetallization while the anodically connected shafts are simultaneously lowered onto the substrate. Simultaneously with the shaft change, the shafts previously connected cathodically are connected anodically so that the material deposited thereon can be removed from them, and the shafts previously connected anodically are connected cathodically so that the electrically conductive structures on the substrate can be coated further. Such a shaft change is preferably carried out while the cathodically connected band section is not actually contacting any structure to be coated. It is nevertheless also possible to provide at least one preferably insulated shaft as a tension shaft so that, for the shaft change, all the shafts are first connected cathodically then the shafts previously connected anodically are lowered onto the substrate, the shafts previously connected cathodically are raised from the substrate and, after they have been raised, connected anodically. When the device is arranged below the substrate, the shafts previously connected cathodically are lowered and subsequently connected anodically, while the shafts previously connected anodically are raised against the substrate and subsequently connected cathodically. When additional insulated transport shafts or tension shafts are provided, the lowering and raising of the shafts as well as the polarity reversal may take place simultaneously.

Besides reversing the polarity of the shafts in order to remove the metal deposited on them, it is also possible to provide shielding on the cathodically connected shafts, which reduces the metal deposition on the shafts. Such shielding is, for example, nonconductive cladding of the shafts which covers the shafts in the regions where they are in contact with the electrolyte solution, the cladding being at a very small distance from the shafts surface and the shafts being exposed only at the positions where the substrate and/or the bands are contacted.

In a further method variant, the substrate to be coated is rotated through a predetermined angle after passing through the electrolytic coating device. After the rotation, the substrate passes either through the device for a second time or through a second corresponding device. The angle through which the substrate is rotated preferably lies in the range of from 10° to 170° , more preferably in the range of from 50° to 140° , in particular in the range of from 80° to 100° , and more particularly preferably the angle through which the substrate is rotated is essentially 90° . Essentially 90° means that the angle through which the substrate is rotated does not differ by more than 5° from 90° . The device for rotating the

substrate may be arranged inside or outside the bath. In order to coat the same side of the substrate again, for example so as to achieve a greater layer thickness of the metal layer, the rotation axis is perpendicular to the surface to be coated. When another surface of the substrate is intended to be coated, the rotation axis
5 should be arranged so that after the rotation the substrate is positioned in such a way that the surfaced intended to be coated next points in the direction of the cathode.

The layer thickness of the metal layer deposited on the electrically conductive structure by the method according to the invention depends on the contact time,
10 which is given by the speed with which the substrate passes through the device and the number of bands positioned in series, as well as the current strength with which the device is operated. A longer contact time may be achieved, for example, by connecting a plurality of devices according to the invention in series
15 in at least one bath.

In one embodiment, a plurality of devices according to the invention are connected in series respectively in individual baths. It is therefore possible to hold a different electrolyte solution in each bath, so as to deposit different metals
20 successively on the electrically conductive structures. This is advantageous, for example, in decorative applications or for the production of gold contacts. Here again, the respective layer thicknesses can be adjusted by selecting the throughput speed and the number of devices with the same electrolyte solution.

25 With the device according to the invention, it is possible to coat all electrically conductive surfaces irrespective of whether the intention is to coat mutually insulated electrically conductive structures on a nonconductive substrate or a full surface. The device is preferably used for coating electrically conductive structures on an electrically nonconductive support, for example reinforced or
30 unreinforced polymers such as those conventionally used for printed circuit boards, ceramic materials, glass, silicon, textiles etc. The electrolytically coated electrically conductive structures produced in this way are, for example, conductor tracks. The electrically conductive structures to be coated may, for example, be made of an electrically conductive material printed on the circuit board. The
35 electrically conductive structure preferably either contains particles of any geometry made of an electrically conductive material in a suitable matrix, or consists essentially of the electrically conductive material. Suitable electrically

conductive materials are, for example, carbon or graphite, metals, preferably aluminum, iron, gold, copper, nickel, silver and/or alloys or metal mixtures which contain at least one of these metals, electrically conductive metal complexes, conductive organic compounds or conductive polymers.

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A pretreatment may possibly be necessary first, in order to make the structures electrically conductive. This may, for example, involve a chemical or mechanical pretreatment such as suitable cleaning. In this way, for example, the oxide layer which is disruptive for electrolytic coating is previously removed from metals. The electrically conductive structures to be coated may, however, also be applied on the printed circuit boards by any other method known to the person skilled in the art. Such printed circuit boards are, for example, installed in products such as computers, telephones, televisions, electrical parts for automobiles, keyboards, radios, video, CD, CD-ROM and DVD players, game consoles, measuring and control equipment, sensors, electrical kitchen equipment, electronic toys etc.

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Electrically conductive structures on flexible circuit supports may also be coated with the device according to the invention. Such flexible circuit supports are, for example, polymer films such as polyimide films, PET films or polyolefin films, on which electrically conductive structures are printed. The device according to the invention and the method according to the invention are furthermore suitable for the production of RFID antennas, transponder antennas or other forms of antenna, chip card modules, flat cables, seat heaters, foil conductors, conductor tracks in solar cells or in LCD/plasma display screens or for the production of electrolytically coated products in any form, for example thin metal foils, polymer supports metal-clad on one or two sides with a defined layer thickness, 3D-molded interconnect devices or else for the production of decorative or functional surfaces on products, which are used for example for shielding electromagnetic radiation, for thermal conduction or as packaging. It is furthermore possible to produce contact sites or contact pads or interconnections on an integrated electronic component.

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After leaving the electrolytic coating device, the substrate may be further processed according to all steps known to the person skilled in the art. For example, remaining electrolyte residues may be removed from the substrate by washing and/or the substrate may be dried.

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The device according to the invention for the electrolytic coating of electrically conductive substrates or electrically conductive structures on electrically nonconductive substrates may, according to requirements, be equipped with any auxiliary device known to the person skilled in the art. Such auxiliary devices are,
5 for example, pumps, filters, supply instruments for chemicals, winding and unwinding instruments etc.

All methods of treating the electrolyte solution known to the person skilled in the art may be used in order to shorten the maintenance intervals. Such treatment
10 methods, for example, are also systems in which the electrolyte solution self-regenerates.

The device according to the invention may also be operated, for example, in the pulse method known from Werner Jillek, Gustl Keller, Handbuch der
15 Leiterplattentechnik [handbook of printed circuit technology], Eugen G. Leuze Verlag, 2003, volume 4, pages 192, 260, 349, 351, 352, 359.

The advantage of the device according to the invention and the method according to the invention is that the at least one band provides a greater contact area and
20 therefore a longer contact time per unit area than is the case with rolls such as those known from the prior art. It is therefore possible achieve the desired layer thicknesses of electrically conductive structures within a shorter distance, such that the installations can also be made shorter or operated with a high throughput, so that a lower operating costs are or achieved. Another essential advantage is
25 that now even very short structures, for example those desired in the production of printed circuit boards, can be produced more rapidly, with greater control and above all more reproducibly and with homogeneous layer thicknesses than is possible with the roll systems known from the prior art.

30 The invention will be explained in more detail below with the aid of the drawings. The figures respectively show only one possible embodiment by way of example. Other than in the embodiments mentioned, the invention may naturally also be implemented in further embodiments or in a combination of these embodiments.

35 Figure 1 shows a plan view of a device designed according to the invention with a plurality of bands arranged offset in series,

Figure 2 shows a side view of the device according Figure 1,

Figure 3 shows a side view of a device designed according to the invention with bands which rest on the shaft,

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Figure 4 shows a plan view of a device according Figure 3,

Figure 5 shows a side view of a device designed according to the invention with bands which rest in grooves of the shaft,

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Figure 6 shows a plan view of a device according Figure 5,

Figure 7 shows a side view of a device designed according to the invention with cathodically and anodically connected shafts,

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Figure 8 shows a detail of a band as used, for example, in Figure 7,

Figure 9 shows a detail of a device designed according to the invention, in which the anodically and cathodically connected shafts can be raised or lowered,

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Figure 10 shows a device according to the invention in which the upper and lower sides of a substrate can be coated,

Figure 11 shows a device with which upper and lower sides of a substrate can be coated, in which bands are arranged offset in series,

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Figure 12 shows an enlarged representation of a detail of a band in a first embodiment,

Figure 13 shows an enlarged representation of a detail of a band in a second embodiment,

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Figure 14 shows a plan view of a detail of a band in a third embodiment,

Figure 15 shows a side view of the band according to Figure 14,

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Figure 16 shows a side view of a device according to the invention with

segmented shafts,

Figure 17 shows a side view of anodes during the electrolytic coating,

- 5 Figure 18 shows a side view of the anodes according to Figure 17 when changing the shafts.

Figure 1 shows a plan view of a cathode designed according to the invention, in which a plurality of bands are arranged offset in series.

10

A cathode 1 comprises a plurality of bands 2, which are respectively guided via two shafts 3. Bands 2 lying next to each other are in this case arranged so that a gap 4 is formed between them. The width of the gap 4 is in this case preferably greater than or equal to the width of a band 2. In this way, the bands 2 arranged
15 offset behind the bands 2 of a row can be guided through the gap. In the embodiment represented in Figure 1, one shaft 3 is in this case respectively used as a rear shaft of the bands 2 of a first row and as a front shaft 3 for the bands 2 of the second row. In this way, it is possible to economize on shafts as well as space compared to an arrangement in which the bands arranged offset behind
20 one row are guided around two separate shafts. The coating in the embodiment represented in Figure 1 respectively takes place in the gaps 4 between the bands 2, so long as the electrically conductive structures intended to be coated are touched by a band 2.

- 25 Figure 2 shows a side view of the arrangement in Figure 1.

In the side view represented in Figure 2, it can be seen that the bands 2 are respectively guided around two shafts 3. The shafts are in this case arranged successively in series. The substrate to be coated may be in contact with the
30 cathode 1 either on the upper side 5 or on the lower side 6. In this case, care should respectively be taken merely that the electrically conductive structures to be coated face toward the band 2. When the substrate to be coated is guided along the upper side 5 of the cathode 1, the cathode 1 may simultaneously serve as a transport device as represented in Figure 2. When the substrate to be coated
35 is guided along the lower side 6, a device is additionally provided with which the substrate is placed against the bands 2 so that an electrical contact is made between the lower side 6 of the cathode 1 and the substrate to be coated. This

device is preferably a transport device. Such devices are, for example, conveyor belts or transport shafts.

5 For electrically contacting the bands 2 in the embodiment represented in Figures 1 and 2, at least one shaft 3 around which a band 2 runs is respectively connected cathodically. Furthermore, it is also possible to connect each shaft 3 cathodically.

10 In order to permit electrolytic coating, anodes 31 in addition to the cathode 1 must also be provided in the bath. The cathodes 31 may be arranged either between the shafts 3, as represented in Figure 2, or else above or below the band 2.

A device designed according to the invention, with bands 2 which rest on the shaft 3, is represented in a side view in Figure 3 and in a plan view in Figure 4. The bands 2 are respectively guided around two shafts 3. Since the shafts 3 are
15 designed as cylindrical rolls, the bands 2 rest on the rolls. Contact with the substrate takes place here only through the band. In contrast to this, Figure 5 represents a side view and Figure 6 a plan view of an embodiment in which the bands 2 are held in grooves 30 in the shafts 3. The width of a groove 30 preferably corresponds to the width of a band 2 and the depth of a groove 30
20 preferably to the thickness of a band 2. By holding the bands 2 in the grooves 30, it is possible to avoid axial displacement of the bands 2 on the shafts 3. In an embodiment in which the depth of the groove 30 corresponds to the thickness of a band 2, as represented here, the shaft 3 also rests on the substrate. Additional contacting can thereby take place through the shaft 3.

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Figure 7 shows a further embodiment of an electrolytic coating device according to the invention in a sectional representation.

30 In the embodiment represented in Figure 7, an electrically conductive structure 7 on a substrate 8 is coated with a device designed according to the invention. The device comprises a band 2, which is guided around a plurality of shafts 3. The shafts 3 are arranged in an upper row 9 and a lower row 10. The shafts of the lower row 10 are connected cathodically, while the shafts of the upper row 9 are connected anodically. The voltage of the cathodically connected shafts of the
35 lower row 10 is transmitted to the electrically conductive structure 7 via the band 2. By means of this, the electrically conductive structure 7 is likewise charged negatively so that metal ions of the electrolyte solution, in which the substrate 8

and the device are held, deposit to form a metal layer. Since the shafts 3 of the lower row 10 and the band 2 in the region of the lower row 10 are negatively charged, metal ions likewise deposit on them. So that the metal deposited on the band 2 can be removed again, the upper row 9 is connected anodically. By means
5 of this, the band 2 is charged positively in the region of the upper row 9 and the metal ions pass back into the electrolyte solution. The liquid level of the bath of electrolyte solution is denoted by reference numeral 11 and is represented by a solid line.

10 In addition to the anodically connected shafts of the upper row 9, anodes 31 may be arranged between the cathodes as represented here. The anodes 31 are, for example, designed as flat rods.

So that there is no short circuit in the band 2, the band 2 in the embodiment
15 represented in Figure 7 is constructed as represented in Figure 8. Here, the band 2 comprises electrically conductive sections 12 and electrically nonconductive sections, i.e. insulating sections 13. The length L of an electrically conductive section 12 is preferably greater than or equal to the distance h between two cathodically connected shafts 3. In order to avoid a short circuit, however, the
20 length L of an electrically conductive section 12 must be less than the distance d from a cathodically connected shaft to a neighboring anodically connected shaft.

The transport direction of the substrate 8 is represented by the arrow 14. In order to press the substrate against the band 2, pressure rolls 21 are arranged below
25 the substrate 8. The substrate 8 is guided through between the pressure rolls 21 and the band 2. The required pressure force may be achieved on the one hand in that the pressure rolls 21 are mounted firmly and the shafts 3, around which the band 2 runs, are sprung-mounted and pressed against the substrate 8, or in that the shafts 3 are mounted firmly and the pressure rolls 21 are mounted a mobile
30 fashion and moved against the substrate 8 with the required pressure force. When it is intended that the shafts 3 of the upper row 9 and of the lower row 10 can change their position, it is preferable for the pressure rolls 21 to be mounted firmly and for the required application pressure to be applied onto the substrate 8 by the mobile shafts 3 of the lower row 10.

35 Instead of the individual pressure rolls 21 as represented in Figure 7, it is also possible to use a band which runs around shafts and which, for example, is

constructed like the cathode represented in Figure 2 but without being electrically conductive.

5 In a further embodiment, another electrolytic coating device may be arranged below the substrate 8 instead of the pressure rolls 21. In this case, the substrate 8 can then be coated simultaneously on its upper side and its lower side.

Figure 9 shows a side view of a device designed according to the invention in a further embodiment.

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In the embodiment represented in Figure 9, the shafts of the anodically connected upper row 9 are arranged offset with respect to the shafts of the cathodically connected lower row 10. The distance h between two anodically connected shafts, or between two cathodically connected shafts, is selected respectively so that an
15 anodically connected shaft can be guided through between two neighboring cathodically connected shafts and a cathodically connected shaft between two anodically connected shafts. The arrows 15 in Figure 9 represent the fact that the shafts of the lower row 10 can be raised and the shafts of the upper row 9 can be lowered. This makes it possible for the metal deposited on the cathodically
20 connected shafts to be removed even in continuous production operation. To this end, the cathodically connected shafts of the lower row 10 are raised as represented by the arrows 15, while the shafts of the upper row 9 are lowered as represented by the arrows 16. At the same time, the polarity of the shafts is reversed so that after lowering the upper row 9, these shafts are connected
25 cathodically, and after raising the lower row 10, these shafts are connected anodically. Owing to the polarity change, metal now deposits on the shafts of the upper row 9 which were previously connected anodically but now form the lower row 10 and are connected anodically, while metal is removed from the shafts of the lower row 10 which were previously connected cathodically, so long as they
30 form the upper row 9 and are connected anodically.

Besides the embodiment as represented in Figures 3 and 5, in which all the shafts of the upper row 9 are connected anodically and all the shafts of the lower row 10 are connected cathodically, it is also possible to provide at least one transport
35 shaft which is electrically nonconductive in each row. Preferably, the transport shafts are respectively the first and/or last shaft of a row 9, 10.

So that all the metal can be removed again from the shafts 3 and the bands 2, at least as many shafts 3 are connected anodically as cathodically. The number of the anodically connected shafts is preferably greater than that of the cathodically connected shafts. In order to achieve this, for example in the embodiment
5 represented in Figure 9, the first shaft of the upper row 9 always remains connected anodically and stays in its position.

Figure 10 shows an electrolytic coating device in a further embodiment.

10 In the device represented in Figure 10, the substrate 8 is coated simultaneously on the upper and lower sides. To this end, the substrate 8 is guided through between an upper device 17 and a lower device 18. The distance between the upper device 17 and the lower device 18 is selected so that it corresponds precisely to the thickness of the substrate 8.

15 In the embodiment represented here, the shafts 19 next to the substrate are respectively connected cathodically, while the shafts 20 remote from the substrate are connected anodically. In the embodiment represented in Figure 10 as well, the shafts 19 can preferably be raised from the substrate 8 and the shafts 20 lowered
20 onto the substrate 8. The polarity of the shafts is simultaneously reversed, so that the shafts 20 are connected cathodically as soon as they contact the substrate 8, and the shafts 19 are connected anodically as soon as they are raised from the substrate 8. In the embodiment represented here, a plurality of bands 2 are arranged in series on the upper side and the lower side of the substrate 8. The
25 bands 2 are respectively guided around separate shafts. The successively arranged bands 2 are preferably arranged mutually offset.

The embodiment represented in Figure 11 corresponds substantially to the embodiment represented in Figure 10. However, a cathodically connected shaft
30 19 and an anodically connected shaft 20 respectively form the rear shaft of a band 2 and simultaneously the front shaft of a further band 22, which is represented here by dashes. In plan view, the arrangement of the bands 2 and of the further bands 22 represented by dashes corresponds to the arrangement represented in Figure 1. Here, the bands 22 are respectively arranged offset behind the bands 2.

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Figure 12 represents an enlarged representation of a first embodiment of a band designed according to the invention with electrically conductive sections and

electrically nonconductive sections.

The band 2 schematically represented here is constructed from individual conductive segments 23 and nonconductive segments 24. The individual segments 23, 24 are respectively fastened to one another by brackets 25. The length of the conductive sections is established by the number of conductive segments 23 which are fastened together. An electrically nonconductive section is in each case arranged between two conductive sections. In general, it is sufficient merely to use a single electrically nonconductive segment 24 for the electrically nonconductive section. It is nevertheless also possible to arrange a plurality of nonconductive segments 24 in series.

Figure 13 represents a further embodiment of a band 2. The band 2 is made from a flexible support 26, around which an electrically conductive wire 27 is wound in order to produce an electrically conductive section 12. A suitable flexible support 26 is, for example, a nonconductive plastic band which is optionally made of an elastomer. Instead of the electrically conductive wire 27 represented in Figure 13, for example, an electrically conductive foil may be wound around the flexible support 26 in order to produce the electrically conductive section 12.

A further embodiment of a band 2 is schematically represented in a plan view in Figure 14 and a side view in Figure 15. The band 2 represented here comprises two flexible nonconductive supports 26, on which conductive sections 32 are fastened at a regular spacing. The conductive sections 32 may, for example, be fastened on the conductive supports 26 by adhesive bonding. The conductive sections 32 may be either rigid or flexible. In the case of rigid conductive sections 32, their width is preferably selected so that they can run around the shafts 3. To this end, it is necessary for the width of the conductive sections 32 to be less than the radius of the shaft 3. If the conductive sections 32 are intended to be made wider, they are preferably made of this flexible material. A suitable material is, for example, a likewise flexible metal foil. The nonconductive support 26 and/or the conductive sections 32 of the band 2 may also be provided with holes or designed in the form of a network.

Besides the embodiments of the bands 2 with electrically conductive sections 12 and electrically nonconductive sections 13 as represented in Figures 12 to 15, any other structure known to the person skilled in the art from which a band, which

alternately has electrically conductive and electrically nonconductive sections, can be produced is possible. For example, it is possible to provide a network structure as the band 2, an electrically conductive network being connected to an electrically nonconductive network, wire or polymer support in order to form the electrically conductive sections 12 and electrically nonconductive sections 13. For example, the electrically conductive sections in the form of a network may then be connected to the meshes of a nonconductive section with the aid of a wire which is guided through the individual meshes of the network structure.

Figure 16 shows an embodiment of a device designed according to the invention, in which the shafts 3 are constructed from individual conductive segments 35 and nonconductive segments 36. The conductive segments 35 and the nonconductive segments 36 are arranged alternately. This makes it possible for a conductive segment 35 to be connected cathodically and for a neighboring conductive segment 35, which is separated from the cathodically connected segment 35 by a nonconductive segment 36, to be connected anodically. In order to prevent a short circuit, it is necessary for the band 2 running around the shafts 3 to be configured with individual conductive 12 and electrically nonconductive sections 13. The nonconductive sections 13 of the band 2 must be arranged so that they respectively rest on a nonconductive segment 36 of the shaft. Removal of the metal deposited on the cathodically connected segment 35 of the shaft and the cathodically connected section 12 of the band 2 is achieved by connecting them anodically in a further revolution. To this end, sliding contacts 37, 38 are preferably provided on the shafts 3. The first sliding contact 37 is used as an anode, and the second sliding contact 38 as a cathode. So long as a conductive segment 35 is in contact with the first sliding contact 37, this segment 35 is connected anodically, and it is connected cathodically as soon as it comes in contact with the second sliding contact 38. Besides the sliding contacts 37, 38 described here, it is also possible to use any other contact which does not hinder rotation of the shafts 3, and with which the conductive segments 35 can be selectively connected cathodically and anodically. The distance between the anode 37 and the cathode 38 must be large enough to prevent simultaneous contact of the anode 37 and cathode 38 with a conductive segment 35.

Owing to the anodically connected electrically conductive segments 35, in the embodiment represented in Figure 16 it is not necessary to provide further additional anodes. It is nevertheless possible to arrange further anodes between

the shafts 3, for example in the form of flat rods.

Figure 17 shows a side view of anodes during the electrolytic coating.

- 5 Figure 18 shows the anodes in a position when the shafts 3 (which are not represented here) change their position.

If anodes 31 are provided in addition to the anodically connected shafts 3 or electrically conductive segments of the shafts 3, they may for example be
10 constructed as represented in Figures 17 and 18.

During the coating process, the anodes 31 are in their deployed position. For a substrate 8 which is coated simultaneously on the upper side and the lower side, they are then arranged above and below the substrate 8. When only one side of
15 the substrate 8 is coated, the anode 31 is preferably arranged on the side of the substrate 8 which is coated. In this case, care should be taken that the anode 31 does not touch the substrate. Otherwise, on the one hand, a short circuit could occur when the cathode touches the same electrically conductive structure as the anode, and on the other hand metal previously deposited on the structure would
20 be removed again during the contact with the anode 31.

In order to make it possible to change the shafts, the anodes 31 can be moved parallel to the surface of the substrate 8 which is to be coated, as represented by the double arrow 41 in Figure 18. The movement takes place transversely to the
25 direction in which the substrate is transported through the bath. This makes it possible to remove the anodes while the shafts 3 change their position. Damage of the anodes 31 and shafts 3 is thereby avoided. In the embodiment represented here, the anodes 31 are made of a flexible material. This makes it possible for the anodes to be wound in respectively allocated anode winding/unwinding devices
30 40 and unwound therefrom. The anode winding/unwinding devices 40 are preferably arranged above and below the bath, as represented here. Such windable and unwindable anodes are, for example, made in the form of flexible metal bands or resilient spirals. If the anodes made of resilient spirals, a plurality of the spirals are preferably fastened next to one another.

List of References

- 1 cathode
- 2 band
- 3 shaft
- 5 4 gap
- 5 upper side
- 6 lower side
- 7 electrically conductive structure
- 8 substrate
- 10 9 upper row
- 10 lower row
- 11 liquid level
- 12 electrically conductive section
- 13 electrically nonconductive section
- 15 14 transport direction
- 15 movement direction of the shafts
- 16 movement direction of the shafts
- 17 upper device
- 18 lower device
- 20 19 cathodically connected shafts
- 20 anodically connected shafts
- 21 pressure roll
- 22 further band
- 23 conductive segment
- 25 24 nonconductive segment
- 25 bracket
- 26 flexible support
- 27 wire
- 30 groove
- 30 31 anode
- 32 conductive section
- 35 conductive segment
- 36 nonconductive segment
- 37 anode
- 35 38 cathode
- 40 anode winding/unwinding device
- 41 movement direction of the anode

d distance between a cathodically connected shaft and an anodically connected shaft

h distance between two cathodically connected shafts

L length

Patent claims

1. A device for the electrolytic coating of at least one electrically conductive substrate (8) or a structured or full-surface electrically conductive surface on a nonconductive substrate (8), which comprises at least one bath, one anode and one cathode (1), the bath containing an electrolyte solution containing at least one metal salt, from which metal ions are deposited on electrically conductive surfaces of the substrate (8) to form a metal layer while the cathode (1) is brought in contact with the surface to be coated of the substrate (8) and the substrate is transported through the bath, wherein the cathode (1) comprises at least one band (2) having at least one electrically conductive section, which is guided around at least two rotatable shafts (3, 19).
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2. The device as claimed in claim 1, wherein at least one of the shafts (3, 19, 20) is electrically conductive, the voltage supply taking place via the shafts (3, 19, 20).
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3. The device as claimed in claim 1 or 2, wherein a plurality of the bands (2) are arranged offset in series.
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4. The device as claimed in claim 3, wherein respectively successive bands (2) arranged offset are guided via at least one common shaft (3).
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5. The device as claimed in one of claims 1 to 3, wherein at least one band (2) is designed in the form of a network or has holes.
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6. The device as claimed in claim 5, wherein the band designed in the form of a network comprises sections of different mesh width and/or mesh shape and/or offset meshes.
7. The device as claimed in claim 5, wherein the band provided with holes comprises sections with differently large holes and/or differently shaped holes and/or offset holes.

8. The device as claimed in one of claims 1 to 7, wherein the at least one band (2) alternately comprises conductive sections (12) and nonconductive sections (13).
- 5 9. The device as claimed in claim 8, wherein the band (2) is additionally guided around at least one anodically connected shaft (3, 20).
- 10 10. The device as claimed in claim 9, wherein the length (L) of the conductive sections (12) is greater than or equal to the distance (h) between the at least two cathodically connected shafts and less than the distance (d) between a cathodically connected shaft and a neighboring anodically connected shaft.
- 15 11. The device as claimed in one of claims 1 to 10, wherein the device furthermore comprises a device with which the substrate (8) can be rotated, the device being arrangeable inside or outside the bath.
- 20 12. The device as claimed in one of claims 1 to 11, wherein at least two bands (2) are arranged so that the substrate (8) to be coated can be guided through between them and the bands (2) respectively contact the upper side and the lower side of the substrate (8).
- 25 13. The device as claimed in one of claims 1 to 12, wherein the shafts (3) can be connected both cathodically and anodically and can be lowered onto the substrate (8) or raised from the substrate (8).
- 30 14. The device as claimed in one of claims 1 to 13, wherein the conductive sections (12) of the at least one band (2) and the shaft surfaces are made of an electrically conductive material which does not pass into the electrolyte solution during operation of the device.
- 35 15. The device as claimed in one of claims 1 to 14, wherein in order to coat flexible supports which are unwound from a first roll and wound onto a second roll, a plurality of devices, a plurality of bands (2) guided around at least two shafts (3) are arranged above one another or next to one another, the flexible support passing through the bands (2) in a meandering fashion.

16. The device as claimed in one of claims 1 to 8, wherein the shafts (3) are constructed from a plurality of electrically conductive segments (35) which are respectively separated from one another by nonconductive segments (36), the electrically conductive segments (35) being connectable both cathodically and anodically and the at least one band (2) being constructed from conductive sections (12) and nonconductive sections (13) and being positioned on the shafts (3) so that a nonconductive section (13) of the band (2) rests on a nonconductive segment (36) of the shaft (3).
17. The device for the electrolytic coating of at least one electrically conductive substrate or an electrically conductive surface on a nonconductive substrate, which device comprises a plurality of devices as claimed in one of claims 1 to 16, which are connected in series.
18. A method for the electrolytic coating of at least one substrate, which is carried out in a device as claimed in one of claims 1 to 17, the band resting on the substrate for the coating and being circulated with a circulation speed which corresponds to the speed with which the substrate is guided through the bath.
19. The method as claimed in claim 18, wherein the at least one band is supplied with voltage via at least one shaft.
20. The method as claimed in claim 18 or 19, wherein the cathodically connected shafts are raised and connected anodically in order to demetallize them.
21. The method as claimed in claim 18 or 19, wherein the shafts are connected anodically for demetallization during a production pause.
22. The method as claimed in claim 18 or 19, wherein the band runs around at least one further shaft which is connected as an anode, the band alternately having conductive and nonconductive sections, the length of the conductive sections being less than the distance between a shaft connected as an anode and a shaft connected as a cathode and the band contacting the substrate with the region between two shafts, with which it is cathodically connected.

23. The method as claimed in claim 22, wherein the cathodically connected shafts are raised and connected anodically in order to demetallize them, while the anodically connected shafts are lowered and connected cathodically.
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24. The method as claimed in one of claims 18 to 23, wherein the substrate is rotated through a predetermined angle after passing through the device, and subsequently passes through the device for a second time or through a second electrolytic coating device.
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25. The method as claimed in one of claims 18 to 24, wherein in order to adjust the layer thickness of the metal layer with which the electrically conductive substrate or the electrically conductive structure on an electrically nonconductive substrate is coated, the contact time is adjusted by increasing or reducing the throughput speed and/or the number of successively connected devices as claimed in one of claims 1 to 16.
15
26. A use of the device as claimed in one of claims 1 to 17 for the electrolytic coating of at least one electrically conductive substrate or a structured or full-surface electrically conductive surface on a nonconductive substrate.
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27. The use of the device as claimed in one of claims 1 to 17 for the production of conductor tracks on printed circuit boards, RFID antennas, transponder antennas or other antenna structures, chip card modules, flat cables, seat heaters, foil conductors, conductor tracks in solar cells or in LCD/plasma display screens or for the production of electrolytically coated products in any form.
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28. The use of the device as claimed in one of claims 1 to 17 for the production of decorative or functional surfaces on products which are used for shielding electromagnetic radiation, for thermal conduction or as packaging.
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29. The use of the device as claimed in one of claims 1 to 17 for the production of thin metal foils or polymer supports clad with metal on one or two sides.
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