US 20120298515A1

(19) **United States**

(12) **Patent Application Publication**

Skupin et al.

(10) **Pub. No.: US 2012/0298515 A1**

(43) **Pub. Date: Nov. 29, 2012**

(54) **METHOD AND DEVICE FOR THE WET-CHEMICAL TREATMENT OF MATERIAL TO BE TREATED**

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(21) Appl. No.: **13/519,816**

(22) PCT Filed: **Dec. 28, 2010**

(86) PCT No.: **PCT/EP2010/007970**

§ 371 (c)(1),
(2), (4) Date: **Aug. 17, 2012**

(30) **Foreign Application Priority Data**

Dec. 28, 2009 (DE) 10 2009 060 676.9

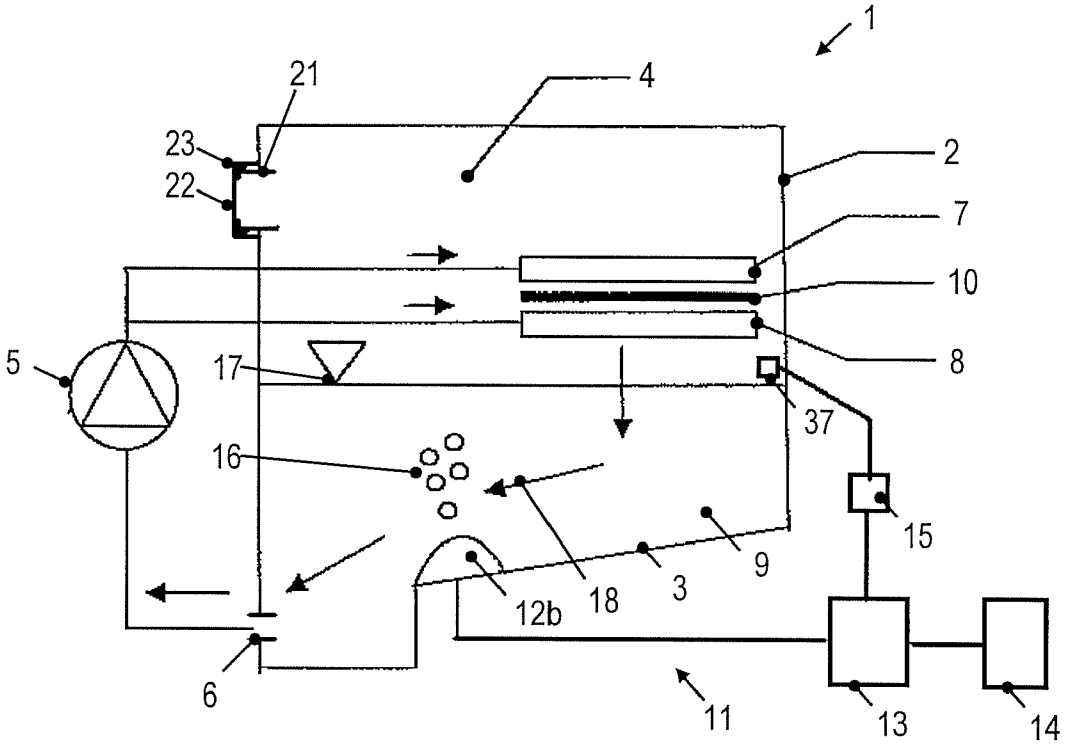
Publication Classification

(51) **Int. Cl.**
C25D 21/18 (2006.01)
C25D 19/00 (2006.01)

(52) **U.S. Cl.** **205/99**; 205/98; 204/232

(57) **ABSTRACT**

A device (**1**) for the wet-chemical treatment of material to be treated (**10**), in particular of flat material to be treated (**10**), comprises a treatment vessel (**2**) for treating the material to be treated (**10**) with a treatment liquid (**9**), a transport device (**24**) for transporting the material to be treated (**10**) through the treatment vessel (**2**), and a feed device (**11**) for feeding an inert gas (**16**) into the treatment vessel (**2**).



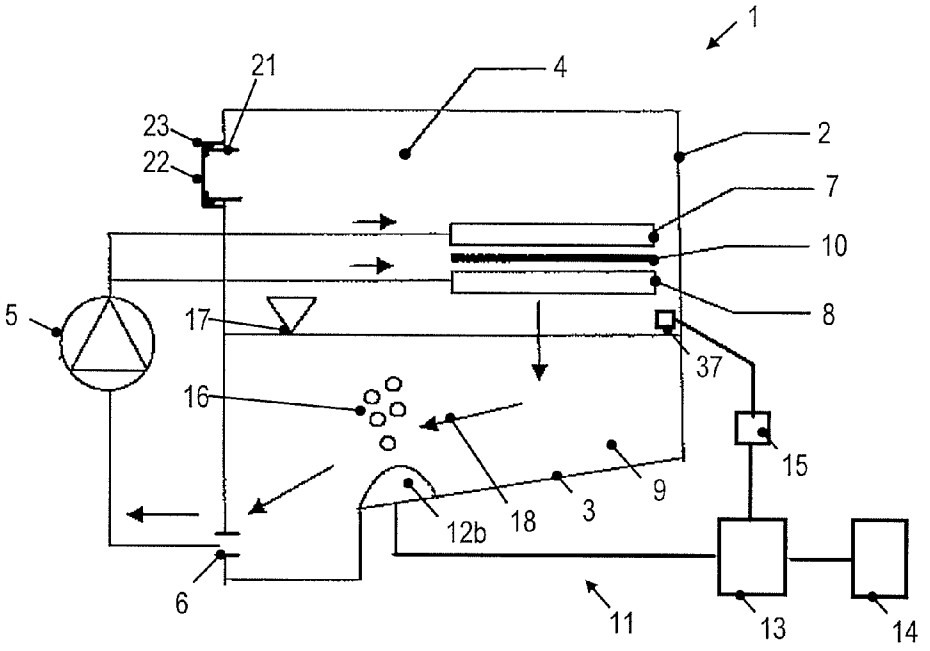

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Fig. 1

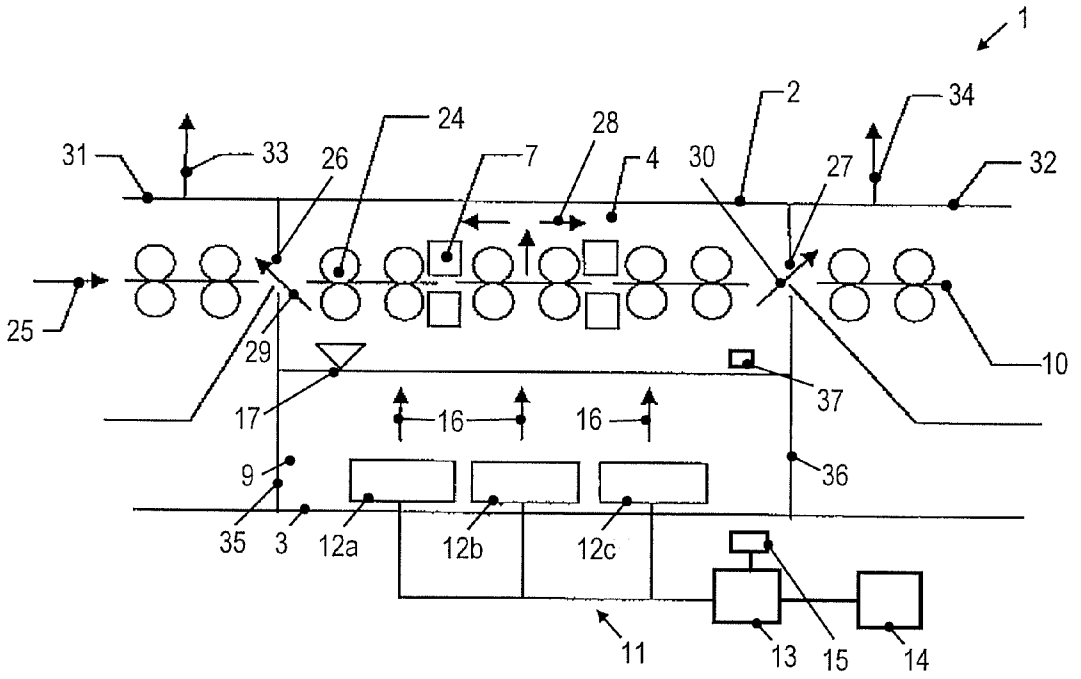

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Fig. 2

METHOD AND DEVICE FOR THE WET-CHEMICAL TREATMENT OF MATERIAL TO BE TREATED

[0001] The invention relates to a method and a device for the wet-chemical treatment of material to be treated. The invention relates in particular to such a device and such a method in which material to be treated is transported and treated with treatment liquid in a continuous process plant.

[0002] In the processing of flat material to be treated, such as, for example, printed circuit boards in the printed circuit board industry, treatment of the material to be treated frequently takes place in a wet-chemical process line. In a continuous process plant, the material to be treated can be transported through one treatment module or a plurality of treatment modules in which it is treated with one treatment solution or, sequentially, with different treatment solutions. The treatment solution can be conveyed to the material to be treated by means of a pump and can be delivered via treatment members. Atmospheric oxygen can thereby enter the treatment solution.

[0003] In some treatment solutions, the introduction of oxygen can impair the treatment solution itself and/or the process of treating the material to be treated. For example, the introduction of oxygen can promote oxidation processes in an electrolyte solution. An example of a treatment solution that can be affected by the introduction of oxygen is a tin solution. In EP 545 216 A2, for example, it is described that the introduction of oxygen from the air into a tin bath can lead to an accumulation of Sn(IV) ions as a result of oxidation of Sn(II) ions and to an accumulation of the Cu(I)-thiourea complex to a concentration at which the solubility limit is exceeded and the complex forms a precipitate.

[0004] In general, certain treatment solutions can be affected by the introduction of oxygen in such a manner that particles precipitate and a corresponding slurry forms in the treatment module. This can lead to a reduction in the service life of the bath, which means increased costs for chemicals and maintenance. The slurry can lead to damage to the material to be treated. The slurry can also settle in low-flow areas of the process line, and removal of the slurry can increase the outlay in terms of maintenance.

[0005] The introduction of oxygen can also have the effect that harmful gases can form during the reaction with the material to be treated in the treatment solution, which gases remain dissolved in the bath and lead to a decrease in reactivity.

[0006] A treatment solution in which the introduction of oxygen into the treatment solution has an adverse effect on the treatment solution itself, on the process of treating the material to be treated or on the operation of the process line or of a treatment module is referred to hereinbelow as an oxygen- or air-sensitive treatment solution.

[0007] In order to lessen the effects of the introduction of oxygen into a treatment solution, it is proposed in DE 101 32 478 C1 to bring baths into contact with metallic tin, for example, and thereby regenerate them. Metal ions in a high oxidation state are thereby reduced to metal ions in a low oxidation state. A corresponding regenerator is to be provided for that purpose.

[0008] The object underlying the invention is to provide an improved method and an improved device for the treatment of material to be treated for a continuous process plant. In particular, there is a need for such a method and such a device in which a negative effect on the treatment solution and/or on the process of treating the material to be treated and/or on the operation of the process line or of a treatment module, which can result from the introduction of oxygen, is lessened. In particular, there is a need for such a method and such a device in which those problems can be lessened during the continuous operation of a continuous process plant without substantially affecting the treatment speed.

[0009] According to the invention, the object is achieved by a method and a device as described in the independent claims. The dependent claims define preferred or advantageous embodiments of the invention.

[0010] According to one aspect, a method for the wet-chemical treatment of material to be treated in a continuous process plant is provided, in which method the material to be treated is transported through a treatment vessel and is treated in the treatment vessel with a treatment liquid. According to the invention, an inert gas is fed into the treatment vessel.

[0011] The material to be treated can in particular be flat material to be treated, for example a printed circuit board, a conductive film, a sheet material or the like. The material to be treated can have a conductive structure. The treatment liquid can in particular be a solution in which the introduction of oxygen into the treatment solution has an adverse effect on the treatment solution itself and/or on the process of treating the material to be treated and/or on the operation of the process line or of a treatment module.

[0012] The feeding of inert gas leads to displacement of atmospheric oxygen in the treatment vessel. In the method, the oxygen concentration in the treatment vessel can be reduced and the introduction of oxygen into the treatment liquid can accordingly be reduced. In particular, a gas cushion which contains a small fraction of oxygen or which contains no oxygen can be produced above a bath of the treatment liquid and immediately adjacent to the bath surface. This allows the introduction of oxygen into the treatment solution to be reduced in a continuous process plant in which the material to be treated is transported into the treatment vessel and out of the treatment vessel.

[0013] The feeding of inert gas can take place in a region or regions of the treatment vessel which are spaced from the region or regions in which waste air is discharged from the treatment vessel. For example, the inert gas can be fed into the treatment vessel in at least one first region of the treatment vessel, while the inert gas is discharged, for example removed by suction or drawn off, from the treatment vessel in a second region of the treatment vessel that is spaced from the first region. This makes it possible, by means of a suitable arrangement of the first region and of the second region, for oxygen to be displaced from the treatment vessel.

[0014] The inert gas can be drawn off from the treatment module via an edge region of the treatment vessel. The edge region can be arranged on a section of a jacket of the treatment vessel which delimits the treatment module in the transport direction, for example on a separating wall between the treatment vessel and an adjacent treatment module in the continuous process plant. The feeding of inert gas into the treatment vessel can take place at least in a region that is spaced from the two sections of the jacket of the treatment vessel that delimit the treatment vessel in the transport direction, and in particular substantially centrally between them. This allows oxygen to be displaced over the length of the treatment vessel.

[0015] The treatment vessel can have an inlet slot, through which the material to be treated is transported into the treatment vessel, and an outlet slot, through which the material to be treated is transported out of the treatment vessel, the inert gas being discharged from the treatment vessel through the inlet slot and/or the outlet slot. The inert gas can in particular be removed from the treatment vessel by suction through the inlet slot and through the outlet slot. This allows waste air to be discharged from the treatment vessel through one slot and, in particular, through two slots provided in the treatment vessel for the passage of the material to be treated. Ingress of air into the treatment vessel through those slots can accordingly be prevented.

[0016] A pressure in a vapour space of the treatment vessel can be so adjusted that it is higher than an ambient pressure outside the treatment vessel. As a result, the ingress of atmospheric oxygen from the surroundings into the treatment vessel, for example through the inlet slot and/or the outlet slot, can be reduced.

[0017] The inert gas can be fed into the treatment vessel continuously. As a result, oxygen can be displaced from the treatment vessel during the continuous operation of a continuous process plant.

[0018] The inert gas can be introduced at least into the treatment liquid in order to feed the inert gas into the treatment vessel. This enables oxygen dissolved in the treatment liquid or harmful gases dissolved in the treatment liquid, which form during the treatment process, to be expelled from the treatment liquid when the inert gas is fed into the treatment vessel.

[0019] The inert gas can be introduced into the treatment liquid at a position that is arranged below a bath level of the treatment liquid. In particular, the inert gas can be introduced into the treatment liquid at a position that is arranged at least 10 mm, in particular at least 100 mm, below the bath level. As a result, foam formation can be prevented, uniform bubble distribution can be achieved, and a long contact time between inert gas bubbles and the bath of treatment liquid can be achieved.

[0020] Furthermore, the inert gas can be introduced into the treatment liquid in such a manner that swirling of the bath, or of the treatment liquid, is achieved. As a result, swirling of any slurry that may still be present in residual amounts can be achieved, so that filtering of the slurry is possible more simply. Maintenance intervals can thus be lengthened and higher availability of the process line can be achieved.

[0021] The treatment vessel can have a sump in which the treatment liquid accumulates at least to a level and from which the treatment liquid is conveyed to a treatment member, the inert gas being introduced into the treatment vessel below the level. As a result, the inert gas can purposively be introduced into the treatment liquid in such a manner that treatment liquid having a low oxygen content is conveyed and delivered via one or more treatment members.

[0022] In that manner, oxygen and/or harmful gases can be expelled from a large fraction of the treatment liquid in the treatment vessel.

[0023] The inert gas can be introduced into the treatment liquid in particular in an intake region of a conveyor device which conveys the treatment liquid to a treatment member. In particular, the inert gas can be introduced into the treatment liquid accumulated in the sump at a position or in a region at or in which there is a large amount of liquid flowing to a conveyor device that circulates the treatment liquid and/or at or in which there is a finite flow velocity to an intake opening of the conveyor device.

[0024] The inert gas can be introduced into the treatment liquid accumulated in the sump at a position or in a region which is arranged in the sump higher than an intake opening of the conveyor device. It is thereby possible to avoid the intake of gas bubbles, which could damage the conveyor device.

[0025] A feed device for feeding the inert gas, in particular for introducing the inert gas into the treatment liquid, can be configured such that the inert gas is introduced in the form of fine bubbles. The feed device can have a porous frit via which the inert gas is introduced into the treatment liquid. The feed device can also have a feed section provided with an arrangement of small holes via which the inert gas is introduced into the treatment liquid. The frit or the delivery section can be in the form of a tubular plastics part. When the inert gas is introduced into the treatment liquid in the form of fine bubbles, a high degree of inert gas use can be achieved. In addition, undesirable splashes can be reduced.

[0026] A volume flow rate of the inert gas fed to the treatment vessel can be established in order to achieve a desired oxygen concentration in a vapour space of the treatment vessel. The volume flow rate can be controlled, for example in dependence on known dimensions and operating parameters of the treatment vessel. The volume flow rate can also be adjusted, for example in dependence on an output signal of a sensor which measures an oxygen concentration or another gas concentration in the vapour space of the treatment module.

[0027] The volume flow rate of the inert gas fed to the treatment vessel can be established such that the oxygen concentration in a vapour space of the treatment vessel above the bath level is less than 10 vol. %, in particular less than 5 vol. %, in particular less than 2 vol. %.

[0028] In the method and the device, it is not necessary to lower the oxygen concentration in the vapour space of the treatment vessel to 0 vol. %. In an exemplary embodiment, the volume flow rate of the inert gas fed to the treatment vessel can be so established that the oxygen concentration in a vapour space of the treatment vessel above the bath level is in the range from 0.1 to 15 vol. %, in particular in the range from 3 to 12 vol. %, in particular in the range from 4 to 8 vol. %. It has been shown that, even with such a residual concentration of oxygen, problems that can occur when the material to be treated is treated with an oxygen- or air-sensitive treatment solution can successfully be reduced.

[0029] The amount of inert gas fed to the treatment vessel per unit time can be established such that an amount of waste air discharged from the treatment vessel per unit time is at least 80% of the sum of the inert gas supplied per unit time and an amount of vapour formed per unit time by evaporation of the treatment liquid. The amount of waste air discharged from the treatment vessel per unit time can be at least 90%, in particular at least 100%, of that sum. In an exemplary embodiment, the amount of waste air removed from the treatment vessel per unit time can be from 80% to 120% of that sum. In that manner, vapours that form can safely be removed by suction.

[0030] The volume flow rate of inert gas fed to the treatment vessel can be established such that a ratio between the volume flow rate, measured in m^3/h, and a volume of treatment liquid, measured in m^3, present in the treatment vessel is less than

20:1, in particular less than 10:1. Such volume flow rates of inert gas allow problems that can occur when the material to be treated is treated with an oxygen- or air-sensitive treatment solution to be prevented and the consumption of inert gas to be kept sufficiently low.

[0031] The treatment vessel can have maintenance and service openings, each of which can be provided with at least one closing element. The at least one closing element can be provided with a gasket. This allows the ingress of oxygen from the surroundings of the treatment vessel via the maintenance and service openings to be prevented.

[0032] Nitrogen or carbon dioxide, for example, can be used as the inert gas.

[0033] According to a further aspect, a device for the wet-chemical treatment of material to be treated, in particular of flat material to be treated, is provided. The device comprises a treatment vessel for treating the material to be treated with a treatment liquid, a transport device for transporting the material to be treated through the treatment vessel, and a feed device for feeding an inert gas into the treatment vessel.

[0034] Because the device is configured to feed inert gas into the treatment vessel, atmospheric oxygen in the treatment vessel can be displaced. The device is accordingly configured to reduce the oxygen concentration in the treatment vessel and accordingly the introduction of oxygen into the treatment liquid. In particular, a gas cushion which contains a small fraction of oxygen or no oxygen can be produced above a bath of the treatment liquid and immediately adjacent to the bath surface. This allows the introduction of oxygen into the treatment solution in a continuous process plant to be reduced.

[0035] The device can be configured to carry out the method according to the various exemplary embodiments described herein, it being possible for the effects described in connection with the corresponding embodiments of the method to be achieved. Embodiments of the device are also described in the dependent claims, it being possible in each case for effects described in connection with the corresponding embodiments of the method to be achieved.

[0036] According to a further aspect of the invention there is provided an article, in particular a printed circuit board or a conductive foil, which has been treated by the method according to an aspect or exemplary embodiment.

[0037] Methods and devices according to various exemplary embodiments of the invention allow the introduction of oxygen into a treatment liquid to be reduced. In particular, in a continuous process plant in which material to be treated is transported into a treatment vessel and, after treatment with the treatment liquid, is transported out of the treatment vessel, problems that can result from the introduction of oxygen into the treatment liquid can be lessened by means of methods and devices according to various exemplary embodiments.

[0038] Exemplary embodiments of the invention can be used in plants in which material to be treated is transported, for example in plants for the chemical, in particular electrochemical, treatment of printed circuit boards, foil-like material, strip conductors or the like. The exemplary embodiments are not limited to that field of application, however.

[0039] The invention is explained in greater detail hereinbelow by means of a preferred or advantageous exemplary embodiment, with reference to the accompanying drawings.

[0040] FIG. **1** is a schematic sectional view of a device for the treatment of flat material to be treated, according to one exemplary embodiment.

[0041] FIG. **2** is a further schematic sectional view of the device of FIG. **1**.

[0042] The exemplary embodiments are described within the context of a plant for the treatment of material to be treated in which the material to be treated is transported in a horizontal transport plane. As is conventional, directions or positions relating to the material to be treated are described in relation to the transport direction. The direction which is parallel, or antiparallel, to the transport direction on transport of the material to be treated is referred to as the longitudinal direction.

[0043] FIG. **1** and FIG. **2** show schematic sectional views of a device **1** for the treatment of flat material to be treated **10**, which can be, for example, a printed circuit, such as a printed circuit board, conductive foil or the like. In the sectional view of FIG. **1** the drawing plane is oriented orthogonally to the transport direction **25**, and in the sectional view of FIG. **2** the drawing plane is oriented parallel to the transport direction **25**.

[0044] The device **1** comprises a treatment module having a treatment vessel **2** in which the material to be treated is treated with a treatment liquid. The treatment liquid can in particular be an oxygen- or air-sensitive treatment solution, for example a chemical tin bath. The treatment module with the treatment vessel **2** can be part of a process line having further treatment modules **31**, **32**, which are arranged adjacent to the treatment module with the treatment vessel **2** and in which the material to be treated **10** is respectively treated with a different process chemical or with a rinsing liquid. In the treatment vessel **2**, the material to be treated **10** can be brought into contact with the treatment liquid in a conventional manner. For example, the treatment vessel **2** can have a sump **3** in which the treatment liquid **9** accumulates to a level **17**. A further region in the treatment vessel **2**, which is referred to hereinbelow as the vapour space **4**, is not filled with treatment liquid and can contain various gases. In embodiments, the vapour space **4** can be defined as the partial volume of the treatment vessel **2** that is not filled with liquid. In the vapour space **4**, evaporated treatment liquid can also be contained in the gas phase.

[0045] The treatment vessel **2** has a housing which defines a jacket of the treatment vessel **2** but does not have to be gas-tight. In particular, in a separating wall **35** which delimits the treatment vessel **2** from the adjacent treatment module **31** in the transport direction **25**, the housing can have an inlet slot **26** via which the material to be treated **10** is transported into the treatment vessel **2**. In a further separating wall **36** which delimits the treatment vessel **2** at its opposite end from the adjacent treatment module **32** in the transport direction **25**, the housing can have an outlet slot **27** via which the material to be treated **10** is transported out of the treatment vessel **2**. A transport device which comprises transport elements, for example pairs of transport rollers **24**, is provided for conveying the material to be treated **10** through the treatment vessel **2**.

[0046] In a lower portion of the treatment vessel **2** there is provided an intake opening **6** with which treatment liquid is conveyed by a conveyor device, for example a pump **5**, from the sump **3** of the treatment vessel **2**. The pump **5** conveys the treatment liquid from the sump **3** to treatment members **7**, **8**, which can comprise a flow nozzle, swell nozzle, spray nozzle or the like. The treatment liquid is delivered from the treatment members **7**, **8** in order to treat with the treatment liquid the material to be treated **10** guided past the treatment mem-

bers **7**, **8**. From the treatment members **7**, **8**, or from the material to be treated **10**, the treatment liquid can flow back into the sump **3** in order to be circulated by the pump **5** again.

[0047] The device **1** is further configured such that an inert gas can be fed into the treatment vessel **2**. The inert gas that is fed can be nitrogen or carbon dioxide, for example. To that end, the device **1** has a feed device **11** for feeding the inert gas. The feed device **11** has a plurality of feed elements **12***a*, **12***b*, **12***c*, from which the inert gas **16** can be delivered, below the level **17**, into the treatment liquid **9** accumulated in the sump **3** of the treatment vessel **2**.

[0048] In order to deliver the inert gas **16** into the treatment liquid **9**, the feed elements **12***a*, **12***b*, **12***c* of the feed device **11** are so positioned that they deliver the inert gas below the level **17** to which the treatment liquid **9** at least accumulates in the sump **3** during operation of the device **1**. The feed elements **12***a*, **12***b*, **12***c* of the feed device **11** can in particular be so positioned that they deliver the inert gas into the treatment liquid **9** at least 10 mm, in particular at least 100 mm, below the level **17**.

[0049] The feed elements **12***a*, **12***b*, **12***c* of the feed device **11** are further so positioned that they deliver the inert gas to the treatment liquid above the intake opening through which the pump **5** conveys the treatment liquid from the sump **3**.

[0050] At least one feed element **12***b* of the feed device **11** is arranged at a distance in the longitudinal direction of the treatment vessel **2** from the two separating walls **35**, **36** which delimit the treatment vessel **2** in the transport direction **25**. The feed element **12***b* of the feed device **11** can in particular be so arranged that it is in any case capable of delivering inert gas **16** into the treatment liquid **9** also at a middle position between the two separating walls **35**, **36**. The inert gas is fed into the treatment vessel **2** by the feed element **12***b* at a position that is spaced from the inlet slot **26** and the outlet slot **27** in the longitudinal direction of the treatment vessel **2**. The feed elements **12***a*, **12***c* of the feed device **11** are also arranged at a distance, in the longitudinal direction of the treatment vessel **2**, from the separating walls **35**, **36** which delimit the treatment vessel **2** in the transport direction **25** and feed the inert gas **16** into the treatment vessel at a position that is remote from the inlet slot **26** and the outlet slot **27** in the longitudinal direction of the treatment vessel **2**.

[0051] At least one feed element **12***b* of the feed device **11**, and advantageously all the feed elements **12***a*, **12***b*, **12***c* of the feed device **11**, are so positioned in the treatment vessel that they deliver the inert gas **16** into the treatment liquid **9** accumulated in the sump **3** at the location where a comparatively large amount of the treatment liquid is rapidly being transported via the intake opening **6** to the pump **5**. To that end, the feed elements **12***a*, **12***b*, **12***c* can be so positioned that they deliver the inert gas **16** into the treatment liquid **9** accumulated in the sump **3** at the location where the accumulated treatment liquid **9** has a finite flow velocity **18** with which the treatment liquid **9** flows to the intake opening **6**. In that manner, a concentration of oxygen or harmful gases in the treatment liquid **9** can be reduced before the treatment liquid **9** is fed to the material to be treated **10** and is circulated. This permits a rapid reduction of atmospheric oxygen and harmful gases in the treatment liquid in the treatment vessel **2**. The swirling of the accumulated treatment liquid **9** resulting from the introduction of inert gas can prevent particles suspended in the treatment liquid from settling and can thus facilitate filtering.

[0052] The feed elements **12***a*, **12***b*, **12***c* of the feed device **11** can each be in the form of a porous frit. Alternatively, the feed elements **12***a*, **12***b*, **12***c* of the feed device **11** can each have an arrangement of small holes through which the inert gas **16** is delivered into the treatment liquid **9**. The feed elements **12***a*, **12***b*, **12***c* can be in the form of plastics parts, in particular in the form of tubular plastics parts.

[0053] A controllable device or a controllable element **13**, for example a controllable valve, is provided in a feed pipe for the inert gas. By means of the controllable device **13**, a volume flow rate of the inert gas from an inert gas reservoir **14** to the feed elements **12***a*, **12***b*, **12***c* can be established. A control means **15** is coupled with the controllable device **13** in order to control or adjust the volume flow rate. The control means **15** can be coupled with a sensor **37** or with a plurality of sensors **37** in the treatment vessel. The sensor **37** or the sensors can be configured to detect the concentration of at least one gas in the vapour space **4**. For example, the sensor **37** can be configured to detect the concentration of oxygen in the vapour space **4** above the accumulated treatment liquid **9** and to supply a signal indicative of the concentration to the control means **15**. Alternatively or in addition, the sensor **37** can be configured to detect the concentration of inert gas in the vapour space **4** and supply a signal indicative of the concentration to the control means **15**. The sensor **37** or the sensors can be configured such that they measure the concentration or concentrations of the corresponding gases above the level **17** of the treatment liquid, in particular just above the level **17** of the treatment liquid. The control means **15** can supply a control signal to the controllable device **13** in response to the detected concentration, in order to adjust the volume flow rate of the inert gas fed into the treatment vessel **2** in dependence on the concentration. In a further exemplary embodiment, the control means **15** can control the volume flow rate of the fed inert gas in dependence on known geometric properties of the treatment vessel **2** and on operating parameters of the device **1**, which can include, for example, the amount of treatment liquid **9** in the treatment vessel **2**.

[0054] Adjusting the volume flow rate of inert gas fed into the treatment vessel by means of the control means **15**, allows the volume flow rate, or the amount, of inert gas that is fed in to be so chosen that it is as small as possible. The volume flow rate of inert gas that is fed can in particular be so chosen that a desired oxygen concentration is achieved in the vapour space **4** of the treatment vessel **2** with the supply of as little inert gas as possible. The feeding of inert gas can be so adjusted that an oxygen concentration of zero does not necessarily have to be achieved. For example, it has been shown that satisfactory results in respect of the introduction of oxygen into the treatment liquid can be achieved if the oxygen concentration in the vapour space **4** above the bath level **17** is less than 10 vol. %, in particular less than 5 vol. %, in particular less than 2 vol. %. The feeding of inert gas can be so adjusted that the oxygen concentration in the vapour space **4** above the bath level **17** is in the range from 0.1 to 15 vol. %, in particular in the range from 3 to 12 vol. %, in particular in the range from 4 to 8 vol. %.

[0055] Further criteria can be used by the control means **15** in order to adjust or control the feeding of inert gas. For example, the control means **15** can adjust the feeding of inert gas in such a manner that a ratio between the volume flow rate of the fed inert gas, measured in m^3/h, and a volume of treatment liquid present in the treatment vessel, measured in m^3, is less than 20:1, in particular less than 10:1.

[0056] As is shown diagrammatically in FIG. **2**, waste air can be removed from the treatment vessel **2** via the inlet slot **26** and the outlet slot **27** through which the material to be treated **10** is transported into the treatment vessel **2** and out of the treatment vessel **2**. The stream of waste air **29** through the inlet slot **26** and the stream of waste air **30** through the outlet slot **27** can substantially contain supplied inert gas **28**, which flows in the vapour space **4** to the inlet and outlet slots **26**, **27**, evaporated treatment liquid as well as amounts of harmful gases or air that has been drawn into the treatment vessel **2**. Air can pass into the treatment vessel **2** via areas that are not leak-tight, for example.

[0057] In order to reduce the ingress of air from the surroundings into the treatment vessel **2**, maintenance and service openings of the treatment vessel **2** can be provided with gaskets. The treatment vessel **2** can, for example, have a maintenance opening **21**, shown diagrammatically, which can be closed by means of a cover **22**. The cover **22** has a gasket **23** in order to prevent the ingress of air.

[0058] The device **1** can be configured such that the waste air **29**, **30** flows from the treatment vessel **2** into the adjacent treatment modules **31**, **32**. In order to prevent air from flowing into the treatment vessel **2** from the treatment modules **31**, **32**, a finite flow velocity of gases through the inlet slot **26** and the outlet slot **27** can be established in the device **1**, the flow velocity being so oriented that the gases flow from the treatment vessel **2** into the adjacent treatment modules **31**, **32**. At intake regions **33**, **34**, which are provided on the adjacent treatment modules **31**, **32**, the waste air can be removed by suction from the treatment vessel **2** via the upstream and downstream treatment modules **31**, **32**.

[0059] As already mentioned, the regions of the treatment vessel **2** at which the feed elements **12***a*, **12***b*, **12***c* feed the inert gas **16** into the treatment vessel **2** are arranged at a distance from the inlet slot **26** and the outlet slot **27** in the transport direction **25**. This assists the distribution of the inert gas **16** along the longitudinal direction of the treatment vessel **2**, and accordingly the displacement of oxygen.

[0060] A suction power and/or the supply of inert gas into the treatment vessel **2** can be so established that air is prevented from entering into the treatment vessel **2** via the inlet and outlet slots **26**, **27**. The suction power can be so chosen that the amount of waste air **26**, **27** removed by suction per unit time is at least equal to the amount of inert gas supplied per unit time plus the amount of treatment liquid evaporated per unit time.

[0061] Modifications to the exemplary embodiment shown in the figures and described in detail can be implemented in further exemplary embodiments.

[0062] Within the context of exemplary embodiments, a device has been described in which the material to be treated is transported horizontally; however, it is also possible in further exemplary embodiments for the material to be treated to be transported in a vertical plane.

[0063] Within the context of exemplary embodiments, devices and methods have been described in which the inert gas is discharged into the treatment liquid accumulated in the sump; however, it is also possible in further exemplary embodiments, alternatively or in addition, for the inert gas to be fed into the treatment vessel at a position or in a region in which no treatment liquid is accumulated.

[0064] Within the context of exemplary embodiments, devices and methods have been described in which treatment members are provided above the liquid level of the accumulated treatment liquid; however, it is also possible in further exemplary embodiments for the material to be treated to be subjected to a dipping treatment. It is not necessarily required that separate treatment members which apply the treatment liquid to the material to be treated are provided.

[0065] The devices and methods according to the various exemplary embodiments can be used in the treatment of articles having conductive structures, such as, for example, printed circuit boards, conductive foils, solar cells or components for solar cells and the like, without their use being limited thereto. The devices and methods according to the various exemplary embodiments can be used in particular in the treatment of material to be treated with oxygen- or air-sensitive treatment solution.

1-14. (canceled)

15. A method for the wet-chemical treatment of material to be treated, in particular of flat material to be treated, in a continuous process plant,

wherein the material to be treated is transported through a treatment vessel and is treated in the treatment vessel with a treatment liquid,

wherein an inert gas is fed into the treatment vessel,

wherein the treatment vessel has an inlet slot, through which the material to be treated is transported into the treatment vessel, and an outlet slot, through which the material to be treated is transported out of the treatment vessel, the inert gas being drawn off from the treatment vessel through the inlet slot and/or the outlet slot.

16. A method according to claim **15**,

wherein the inert gas is fed into the treatment vessel in at least one first region of the treatment vessel, and wherein the inert gas is discharged from the treatment vessel in a second region of the treatment vessel that is spaced from the first region.

17. A method according to claim **15**,

wherein the inert gas is removed from the treatment vessel via an edge region of the treatment vessel.

18. A method according to claim **15**,

wherein a finite flow velocity of gases through the inlet slot and the outlet slot is established, the flow velocity being so oriented that the gases flow from the treatment vessel into adjacent treatment modules, and

wherein intake regions are provided on the adjacent treatment modules to remove waste air by suction.

19. A method according to claim **15**,

wherein the inert gas is introduced at least into the treatment liquid in order to feed the inert gas into the treatment vessel.

20. A method according to claim **15**,

wherein the treatment vessel has a sump in which the treatment liquid accumulates at least to a level and from which the treatment liquid is fed to a treatment member, the inert gas being fed into the treatment vessel below the level.

21. A method according to claim **20**,

wherein the inert gas is introduced into the treatment liquid accumulated in the sump in a region in which there is a finite flow velocity to an intake opening of a conveyor device that conveys the treatment liquid from the sump to the treatment member.

22. A method according to claim **15**,

wherein a volume flow rate of the inert gas fed into the treatment vessel is established such that an oxygen concentration in a vapour space of the treatment vessel is in

the range from 0.1 to 15 vol. %, in particular in the range from 3 to 12 vol. %, in particular in the range from 4 to 8 vol. %.

23. A method according to claim **15**,

wherein the volume flow rate of inert gas fed to the treatment vessel is established such that a ratio between the volume flow rate, measured in m^3/h, and a volume of the treatment liquid, measured in m^3, present in the treatment vessel is less than 20:1, in particular less than 10:1

24. A device for the wet-chemical treatment of material to be treated, in particular of flat material to be treated, comprising

a treatment vessel for treating the material to be treated with a treatment liquid,

a transport device for transporting the material to be treated through the treatment vessel, and

a feed device for feeding an inert gas into the treatment vessel,

the treatment vessel having an inlet slot for introducing the material to be treated into the treatment vessel and/or an outlet slot for discharging the material to be treated from the treatment vessel, and

the device being configured to draw off the inert gas from the treatment vessel through the inlet slot and/or the outlet slot.

25. A device according to claim **24**,

wherein the feed device is configured to feed the inert gas into the treatment vessel in at least one feed region of the treatment vessel, and wherein the treatment vessel has at least one discharge opening for discharging waste air from the treatment vessel, the at least one discharge opening being provided at a distance from the at least one feed region.

26. A device according to claim **24**,

wherein the feed device is configured and disposed to introduce the inert gas into the treatment liquid.

27. A device according to claim **24**,

wherein the treatment vessel has a sump and a conveyor device for conveying treatment liquid from the sump to a treatment member of the treatment vessel, the feed device being configured to introduce the inert gas into a treatment liquid accumulated in the sump.

28. A device according to claim **27**,

wherein the feed device is configured to introduce the inert gas into the treatment liquid accumulated in the sump in a region in which there is a finite flow velocity to an intake opening of a conveyor device, the conveyor device being configured to convey the treatment liquid from the sump to the treatment member

29. A device according to claim **24**,

comprising a control or regulating device for establishing a volume flow rate of the inert gas in order to establish in a vapour space of the treatment vessel an oxygen concentration in the range from 0.1 to 15 vol. %, in particular in the range from 3 to 12 vol. %, in particular in the range from 4 to 8 vol. %.

30. A method for the wet-chemical treatment of material to be treated in a continuous process plant, comprising:

transporting a material to be treated through a treatment vessel and treating the material in the treatment vessel with a treatment liquid,

feeding an inert gas is fed into the treatment vessel,

wherein the treatment vessel has an inlet slot, through which the material to be treated is transported into the treatment vessel, and an outlet slot, through which the material to be treated is transported out of the treatment vessel, the inert gas being drawn off from the treatment vessel through the inlet slot and/or the outlet slot. America **17018213.1**

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