Filling device for filling a bubbler, filling system and soldering or sintering system equipped therewith, and method for operating the filling device

The invention relates to a filling device for filling at least one bubbler, to a filling system and to a soldering or sintering system equipped with said filling system, and to a method for operating the filling device.

PRIOR ART

A crucial component of many industrial manufacturing processes and value-added chains are soldering and sintering systems. A well-known example of this is the manufacture of electronic component parts and electronic assemblies comprising semiconductor components, in particular for the automotive industry, for power generation and for industrial electronics, wherein high-quality intermetallic connections to or between the electronic component parts are manufactured by means of suitably designed and configured soldering and/or sintering systems.

In soldering and sintering processes, it is regularly necessary to dependably free at least those component surfaces to be processed of metal oxides. In low-pressure sintering, diffusion soldering, and low-pressure and vacuum soldering as a sub-group of reflow soldering technology, for example, the removal or reduction of oxide layers is regarded as a standard process. Oxide layers have a very inhibiting effect on soldering processes, and therefore have to be dependably removed to ensure a stable and controllable process.

Soldering systems are understood in particular to be systems for performing vacuum soldering processes and diffusion soldering processes.

To free the surfaces of metal oxides, a process fluid mixed with a process gas is relied on as a rule. Usually, formic acid (HCOOH) is used as the process fluid here, and is as a rule mixed with nitrogen (N2) as the process gas. The reduction and hence removal of oxide layers on component surfaces by means of formic acid (HCOOH) enriched with nitrogen is a stable and economical method in soldering technology, tried and tested in industry over many years. The formic acid has a reducing effect and thus cleans the surface of oxides, to permit high qualities in later processes (soldering, sintering, bonding, welding). Use of fluxes is not necessary with this method.

The use of nitrogen enriched by formic acid as part of the reduction process is performed as

standard with the aid of a so-called bubbler. A bubbler, also referred to as a vapor pressure saturator, is a device normally used for generating process gases in vapor form or enriched with process fluid, said device transferring a liquid starting material, in this case formic acid in a saturated vapor, which is passed into a sintering or soldering chamber by gas bubbles of a carrier gas, as a rule nitrogen N2. The bubbler consists as a rule mainly of a closed container, into which the liquid to be evaporated, or the process fluid, as a rule formic acid, is or has been placed, usually starting from a fluid reservoir, for example a replaceable container or fillable tank. The process gas, as a rule N2, is in turn usually injected, via a bubbler gas supply and via a lance or nozzle pipe with a plurality of openings, into the bottom part of the bubbler container. The process gas (N2) then rises in bubble form through the process fluid (HCOOH) inside the bubbler, while entraining some of the process fluid in vapor form. This resultant process gas/process fluid vapor mixture, i.e. usually nitrogen in vapor form enriched with formic acid, is then fed via gas piping from a bubbler outlet opening into a vacuum chamber as a process chamber of the soldering and/or sintering system, to be used as a reduction means for the component.

A bubbler device of this type is disclosed for example in US 7 025 337 B2. The bubbler device comprises a standard bubbler 12, fillable with a fluid and fluidically coupled to a fluid reservoir by means of a piping system having a plurality of valves. Via the piping system, a process gas and purge gas source, a vacuum source and an outlet are furthermore each fluidically connectable to the bubbler or disconnectable therefrom by means of a plurality of valves. A key function principle is that a fluid level is always kept constant by means of variation of the gas pressure and of the quantity of fluid present in the bubbler or fed into it. This is intended to prevent harmful chemical reactions of the fluid with sensitive parts of the bubbler system. In any event, this publication shows only one fluid reservoir, which may be couplable directly to the outer atmosphere by means of valves.

Due to the continuous consumption of process fluid, it is unavoidable to refill the bubbler regularly with new process fluid. A filling device, which is designed to feed process fluid into the bubbler, in particular starting from the fluid reservoir forming part of the filling device, is usually employed for refilling.

With regard to the filling device, it is known to either fill the bubbler with process fluid directly or replenish it by means of at least one filling valve starting from the fluid reservoir coupled to the bubbler, wherein in the latter case the fluid reservoir must necessarily be replenished after a certain time. For example, in the event that the fluid reservoir is designed as a replaceable container couplable to the bubbler, said container must be decoupled and replaced as soon

as it is empty, and a new full container must be coupled again.

Filling devices of this type for bubblers are known for example from the publications DE 10 2007 024 266 A1, EP 0 949 212 A1 and US 4 276 243 A. These publications each disclose a bubbler system having a bubbler and a filling device, wherein the bubbler is fillable with process fluid from a fluid reservoir via the filling device.

When replenishing the process fluid or filling the bubbler therewith, it is essential to bear in mind that the reduction process for the component surface by means of the process gas/process fluid vapor mixture generated by the bubbler requires the absence of oxygen in the process atmosphere. Failing that, the reduction capacity of the process gas/process fluid vapor mixture will be considerably restricted or directly neutralized again by the oxygen having an oxidizing effect, such that sufficient removal of the oxide layer cannot be effectively achieved. To ensure the absence of oxygen inside the bubbler system, the container from which the process fluid is passed into the process (i.e. either the bubbler itself or the fluid reservoir) must be oxygen-free.

In existing replenishment methods, the pressure needed inside the container for the process must be at atmospheric pressure during replenishment, wherein the integrity of the container is compromised in order to fill it with process fluid. As a result, oxygen may get into this container, and must be removed again before the start of the process, e.g. by purging with inert gas. During the period of filling and during the period in which the oxygen is removed, the process inside the system is halted.

The result of this for known bubbler systems is the recurring problem that operation of the bubbler and/or of the entire system for the intended purpose has to be interrupted at regular intervals in order to fill the bubbler, replenish or replace the fluid reservoir, and to make the entire bubbler system oxygen-free by purging it with inert gas prior to resuming operation. This interruption has the disadvantage that the operating efficiency drops and that the operating costs increase as a result, and in addition contamination, in particular the presence of oxygen when purging is not done correctly, may occur in particular due to the necessary opening of the container, which can reduce the quality of the finished products or sabotage the entire manufacturing process, in particular by damaging the system.

The object of the invention is to provide a filling device improved in that respect and a filling method, in which the aforementioned problems are advantageously solved, enabling in particular automatic filling of the bubbler and replenishment of process fluid into the bubbler and/or fluid reservoir without the necessity for interrupting bubbler operation and/or operation of the

system for the intended purpose. It is a further object of the invention to increase the efficiency and productivity of the process gas supply in a soldering or sintering system.

This object is achieved by a filling device, a bubbler system, a soldering or sintering system, and a method according to the independent claims. Advantageous embodiments of the invention are the subject matter of the sub-claims.

DISCLOSURE OF THE INVENTION

The invention proceeds from a filling device for filling at least one bubbler, also several bubblers, installable or installed in or attached to a soldering or sintering system, in particular a vacuum soldering or diffusion soldering system, with a process fluid, in particular formic acid or another reduction means such as methanoic acid (CH_2O_2) or citric acid, wherein the filling device comprises a fluid reservoir, fluidically couplable or coupled to the bubbler by means of at least one filling valve, to which reservoir the process fluid is controllably suppliable and which is designed to controllably fill the bubbler with the process fluid.

In accordance with the invention, it is provided that the filling device comprises a refilling reservoir which is connected fluidically upstream of the fluid reservoir, to which the process fluid is suppliable starting from a fluid source; wherein the refilling reservoir and the fluid reservoir are controllably connectable by means of at least one supply valve; wherein the refilling reservoir is atmospherically decoupled from the fluid reservoir by a siphon effect when the supply valve is opened, such that the process fluid is always controllably suppliable oxygen-free from the refilling reservoir to the fluid reservoir via the at least one supply valve, and the fluid reservoir always remains oxygen-free.

By means of the siphon-effect atmospheric decoupling from the fluid reservoir and refilling reservoir generated by the opening of the supply valve, the filling device is designed such that on the one hand the bubbler(s) is/are controllably refillable with the oxygen-free process fluid present in the fluid reservoir in automated and/or continuous manner from the oxygen-free fluid reservoir via the filling valve, and on the other hand the fluid reservoir is fillable oxygen-free with the process fluid, fluidically independently of the refilling of the bubbler, without interrupting the operation of the bubbler (independently of bubbler operation) during operation of the

soldering or sintering system for the intended purpose.

The siphon-effect atmospheric decoupling must be understood in connection with the present invention as follows:

it is ensured (structurally) by the shape of the connecting line between the reservoirs, by their design, the valves, the operation of the filling device and/or a regular filling of the refilling reservoir that when the reservoirs are coupled, some fluid always remains or may remain inside the refilling reservoir despite the fluid transfer from the refilling reservoir into the fluid reservoir, such that a siphon effect is created or is present. The process fluid remaining in the refilling reservoir acts as a barrier (siphon) to any gases present in the refilling reservoir, i.e. in particular oxygen.

Due to the siphon effect, the fluid transfer between the refilling reservoir and the fluid reservoir is always oxygen-free, such that oxygen from the refilling reservoir never gets into the fluid reservoir or into connections leading thereto or associated therewith. To that extent, no oxygen can be introduced into the bubbler.

Due to the siphon-effect atmospheric decoupling, there is always a defined residual amount of process fluid present in the refilling reservoir, such that any ingress of oxygen into the fluid reservoir is prevented. This allows the refilling reservoir to be refilled with process fluid while fluidically decoupled from the oxygen-free supply of the bubbler by the fluid reservoir.

As a result, a fluidic independence of the processes of “Reservoir refilling” and “Bubbler filling” is advantageously achieved, rendering interruptions of the system for refilling obsolete. To that extent, it is possible with the solution in accordance with the invention for the one or more bubblers to be filled in automated manner during operational pauses of the soldering system, during which in particular a component to be processed by the system is transported between process chambers. The advantage of this is that during operation of the bubbler, i.e. during operation of the system, the fluid reservoir may already be continuously replenished oxygen-free, such that a constant and above all oxygen-free supply of process fluid is assured. The supply is always assuredly oxygen-free due to atmospheric decoupling by means of the siphon effect, such that operation of the system in principle never has to be interrupted for replenishment – in contrast to solutions known from the prior art.

The refilling reservoir may be replenished at any time regardless of the operation of the bubbler even under ambient air conditions, wherein the introduction of oxygen into the refilling reservoir which this involves is not a problem, since the siphon effect due to atmospheric decoupling

ensures that the ingress of oxygen into the fluid reservoir is prevented.

Advantageously, the operating efficiency is thus considerably increased by the solution in accordance with the invention, saving on effort, time and costs.

According to a preferred development, it is provided that the refilling reservoir and the fluid reservoir are fluidically couplable or coupled by means of the supply valve, such that a gas pressure equalization between the fluid reservoir and the refilling reservoir is achievable by the supply valve. The supply valve may thus be a combined valve (pressure equalization/fluid flow), for example a valve with a non-return characteristic for fluid and pressure. This results in the advantage that the filling device requires fewer parts.

According to an alternative preferred development, it is provided that at least one pressure equalizing valve is provided between the refilling reservoir and the fluid reservoir, wherein the supply valve, in particular designed as a bellows valve, is designed as a fluid flow valve to permit the fluid flow, and the pressure equalizing valve, in particular designed as a bellows or non-return valve, is designed to permit gas pressure equalization. To that extent, the supply valve provided is not, as mentioned above, a combined valve; instead the function of such a combined valve is fulfilled by two separate valves, to wit the fluid flow valve and the pressure equalizing valve. The construction of the filling device is thus advantageously simplified, and easy replacement is possible in the event of a malfunction of a single valve.

Generally speaking, a positive pressure valve in the refilling reservoir may be dispensed with, the latter being connected directly to the waste air. Evaporation losses are in actual practice negligible. According to a preferred development, it may be provided that the refilling reservoir comprises a positive pressure valve for relieving positive pressure, in particular designed as a bellows valve or non-return valve, and/or a fluid connection, in particular with a fluid refilling valve, for the supply, in particular controllable, of process fluid from the fluid source into the refilling reservoir. The refilling reservoir is thus always at normal pressure or at a definable positive or negative pressure. It may be advantageously opened at any time and filled, or the process fluid may be supplied in principle without a (major) pumping capacity.

The fluid connection may be a valve (fluid refilling valve) or a simple aperture of the refilling reservoir, for example also an opened upper side closable with a cover. The fluid source may be an external piping system/network, a (large) tank or the like, in particular placed at a different location than the filling device.

According to a preferred development, it is provided that at least the fluid reservoir, preferably

the refilling reservoir, is designed as a closed, preferably pressure-tight and in particular optionally openable container, wherein the refilling reservoir is arranged higher than the fluid reservoir relative to the ground surface, such that process fluid is suppliable from the refilling reservoir to the fluid reservoir by means of gravity. The refilling reservoir is preferably arranged above or higher than the fluid reservoir, such that process fluid may flow out of the refilling reservoir by means of gravity. Advantageously, the fluid flow is achievable without pumping capacity and requires no pump, or at least requires a comparatively low pumping capacity, such that conveying of the process fluid is both inexpensive and reliable in operation.

Alternatively, it is conceivable to arrange the two containers at the same level and to convey the process fluid by means of a pump. Assistance by pumping capacity may also be provided additionally to the force of gravity even when the two containers are arranged at different heights, for example to permit particularly rapid conveying of the process fluid.

According to a preferred development, it is provided that the refilling reservoir and/or the fluid reservoir has at least one level sensor. The latter is designed to monitor the process fluid level prevailing in the respective reservoir. The siphon effect discussed at the outset can be assured in particular by means of monitoring, and if necessary a (regular) replenishment may be initiated.

Preferably, monitoring and/or replenishment is/are performed in automated manner by at least one control unit using an adapted operating software.

According to a preferred development, it is provided that at least the filling valve is controllable in automated manner, such that the bubbler is refillable automatically and/or continuously with process fluid from the fluid reservoir. Preferably, at least one further valve of the filling device is controllable in automated manner, in particular all valves, i.e. the supply valve, the pressure equalizing valve, the positive pressure valve and/or further valves. As a result, an uninterrupted operation is advantageously ensurable.

A fluid refilling valve between the fluid source and the refilling reservoir is not automatically necessary, because supplying the process fluid may also be directly controlled using a suitable pump or by gravitational pressure, depending on the design. According to a preferred development, it is provided that a fluid refilling valve is arranged between the refilling reservoir and the fluid source for a controllable supply of process fluid from the fluid source into the refilling

reservoir. Advantageously, this dependably ensures a controllable resupply of process fluid to match needs.

According to a preferred development, it is provided that a higher-level control device is comprised which is connected to the filling valve and at least to the supply valve, preferably to the level sensor of the fluid reservoir and/or to the level sensor of the refilling reservoir and/or to the pressure equalizing valve, and the control device is configured to provide a controllable process fluid supply from the fluid reservoir into the bubbler and from the refilling reservoir into the fluid reservoir. Operation of the filling device is as a result advantageously automatable and hence particularly efficiently manageable. The control device may advantageously be part of the system-wide overall control device, or may be independent hereof, and match or synchronize individual procedures of the system with the filling operation using an interface of the overall control device.

The invention furthermore relates to a bubbler system for a soldering or sintering system, having at least one bubbler for supplying a process fluid, in particular formic acid, methanoic acid or citric acid, mixed with a process gas, in particular nitrogen, into at least one process chamber of the soldering or sintering system, and having a filling device for filling the at least one bubbler with the process fluid. The bubbler system is characterized in that the filling device is designed in accordance with the invention, as described above. This results in the advantages already stated previously in this respect.

The invention furthermore relates to a soldering or sintering system with a bubbler system for supplying process fluids, in particular formic acid, methanoic acid or citric acid, mixed with a process gas, in particular nitrogen, into at least one process chamber of the soldering or sintering system. The system is characterized in that the bubbler system is designed in accordance with the invention, as described above. This results in the advantages already stated previously in this respect.

The invention furthermore relates to a method for operating a filling device, in particular the filling device in accordance with the invention as described above.

In this method, it is provided that at least one bubbler installable or installed in a soldering or sintering system is controllably filled with a process fluid by means of the filling device, wherein the bubbler is fluidically coupled by means of at least one filling valve to a fluid reservoir of the

filling device, to which reservoir the process fluid is supplied. Using the filling device, two or more bubblers may also be advantageously filled, which has the advantage that the productivity of the system can be increased with the same acid concentration.

In accordance with the invention, the method is characterized in that fluidically upstream of the fluid reservoir a refilling reservoir of the filling device is connected, to which the process fluid is supplied starting from a fluid source, wherein the refilling reservoir and the fluid reservoir are controllably atmospherically decoupled by a siphon effect by means of at least one supply valve, such that the process fluid is always controllably supplied oxygen-free from the refilling reservoir to the fluid reservoir, and the fluid reservoir is always kept oxygen-free.

This results in the advantages already stated above.

The invention thus comprises a method for operation of the previously mentioned filling device, of the bubbler system and of the soldering or sintering system, wherein said devices have at least one control unit configured to perform the method in accordance with the invention. In other words, the invention thus comprises a method for operating the previously mentioned bubbler system in accordance with the invention or the previously mentioned soldering or sintering system in accordance with the invention, of which the bubbler device is operated accordingly.

According to a preferred development, it may be provided that the bubbler is controllably refilled from the oxygen-free fluid reservoir with the oxygen-free process fluid present in said fluid reservoir via the filling valve, to match demand and/or continuously, preferably in times in which no soldering or sintering process is in progress in the soldering or sintering system, in particular during transfer times of workpieces inside the soldering or sintering system. Both a synchronous and an asynchronous filling (in respect of the replenishment of the fluid reservoir) of the bubbler is possible here. Advantageously, this increases the efficiency of the bubbler’s operation.

According to a preferred development, it may be provided that fluidically independently of refilling of the bubbler, the fluid reservoir is filled oxygen-free with the process fluid by the refilling reservoir, without interrupting the operation of the bubbler, during operation of the soldering or sintering system for the intended purpose, wherein the fluid reservoir is preferably filled with the process fluid while the bubbler is being operated for the intended purpose.

The bubbler is preferably refilled whenever a component to be processed is transferred or moved within the system (from one processing chamber to the next). For refilling, the filling device, in particular its filling valve, is operated in automated manner or a control logic is implemented. Furthermore, operation of the system is not interrupted when the fluid reservoir is being filled. The refilling reservoir may be advantageously filled at any time, and is thus independent of operation/filling of the fluid reservoir, bubbler and system, since the siphon effect prevents any ingress of oxygen and hence atmospheric decoupling is assured. The operating efficiency is further advantageously improved as a result.

According to a preferred development, it may be provided that for the siphon-effect atmospheric decoupling, the fluid reservoir and the refilling reservoir are coupled via the supply valve, in particular designed as a bellows valve, and via a pressure equalizing valve, in particular designed as a bellows valve, wherein the process fluid is controllably supplied from the refilling reservoir to the fluid reservoir via the supply valve, and a gas pressure between the refilling reservoir and the fluid reservoir is equalized using the pressure equalizing valve, wherein a defined residual amount of process fluid always remains inside the refilling reservoir, such that any ingress of oxygen into the fluid reservoir is prevented. The bellows valves are preferably controlled, and may be replaced if applicable by a passive non-return valve. This results in the advantages already stated previously in this respect.

In particular, a positive pressure (in relation to the pressure in the refilling reservoir) prevailing in the fluid reservoir is equalized, i.e. the positive pressure from the fluid reservoir is relieved via the supply valve (or pressure equalizing valve) in the refilling reservoir. Optionally, after pressure equalization between the fluid reservoir and the refilling reservoir a positive pressure (relative to normal pressure) now prevailing in the refilling reservoir is relieved via a positive pressure valve (associated with the refilling reservoir). The residual amount of process fluid remaining ensures that gaseous fluid, in particular oxygen, can at no time get into the fluid reservoir via the supply valve(s), so that said reservoir remains oxygen-free (siphon effect).

According to a preferred development, it may be provided that the process fluid is supplied from the refilling reservoir to the fluid reservoir and/or from the fluid reservoir to the bubbler by means of gravity and/or by means of positive pressure. The process fluid is transferred by force of gravity, and alternatively or additionally by pressure equalization between the reservoirs and the bubbler. In particular, during every transfer step for process fluid a pressure difference prevails between fluidically consecutive volumes (reservoirs/bubbler), wherein the process fluid from the volume with higher pressure (positive pressure) is transferred into that

with a lower pressure relative thereto. This advantageously ensures an efficient and inexpensive fluid flow or transfer.

Alternatively or additionally, the process fluid may be actively pumped (by expending energy) between the volumes, to counteract gravity and pressure from the (spatial) arrangement of the volumes and/or from the (pressure-related) coupling, i.e. to transfer the process fluid from the one volume (initial volume, e.g. refilling reservoir) into the other (fluidically downstream) volume (target volume, e.g. fluid reservoir) despite counteracting forces.

According to a preferred development, it may be provided that a level of the process fluid present in the refilling reservoir and/or in the fluid reservoir is detected by means of a level sensor, wherein a controllable supply of process fluid from the refilling reservoir into the fluid reservoir is triggered in the event that the process fluid level in the fluid reservoir drops below a predeterminable first threshold value, and wherein a controllable supply of process fluid from the fluid source into the refilling reservoir, or at least an instruction to the operator to refill the refilling reservoir from the fluid source is triggered, in the event that the process fluid level in the refilling reservoir drops below a predeterminable second threshold value. As a result, a potential standstill in operation due to a lack of process fluid is advantageously and effectively prevented.

According to a preferred development, it may be provided that during ongoing operation of the soldering or sintering system the following steps are performed for filling the bubbler:

a) in a first step, the process fluid is filled from the fluid source into the refilling reservoir;

b) in a second step, a pressure equalizing valve is opened to equalize the pressure between the fluid reservoir under positive pressure and the refilling reservoir, wherein a positive pressure can preferably escape into the atmosphere via a positive pressure valve of the refilling reservoir, or a positive pressure is emitted directly into the atmosphere, since evaporation losses are negligible;

c) in a third step, the supply valve is opened to supply the process fluid from the refilling reservoir to the fluid reservoir;

d) in a fourth step, the supply valve and the pressure equalizing valve are closed;

e) in a fifth step, the filling valve between the fluid reservoir and the bubbler is opened in order to perform a pressure equalization between the pressures prevailing in the bubbler and in the fluid reservoir respectively;

f) in a sixth step, preferably during non-activity of the bubbler, preferably in times in which no soldering or sintering process is in progress in the soldering or sintering system, specifically during transfer times of workpieces inside the soldering or sintering system, a gas pressure in the bubbler is reduced and the filling valve is opened to supply process fluid from the fluid reservoir into the bubbler;

g) in a seventh step, a positive pressure is restored in the bubbler and the filling valve is closed again.

According to a preferred development, it may be provided that for the removal of oxygen from the filling device, in particular during initial commissioning, for maintenance purposes, and/or for the initial filling of the filling device with process fluid, and preferably repeatedly when a process fluid minimum of preferably 2.5 litres is reached, the following steps are performed one after the other:

I. A respective gas pressure in the bubbler is reduced, preferably within 10s, to below 10 mbar;

II. A gas pressure in the fluid reservoir is reduced, preferably within 10s, to below 10 mbar;

III. All valves between the refilling reservoir, the fluid reservoir and the bubbler are opened;

IV. The bubbler is subjected to pressure while being purged with a process gas for at least 2 min, wherein a positive pressure escapes via a positive pressure valve of the refilling reservoir;

V. All valves between the refilling reservoir, the fluid reservoir and the bubbler are closed.

In the prior art, typical filling levels of between 127 mm min to max. 191 mm and standard flooding rates of <=15 l/min of a process gas enriched by a bubbler are achievable. An internal pressure in the bubbler drops here to 400 mbar or less. According to a preferred development of the filling method, the bubbler may be filled to a predeterminable filling level, preferably to a filling level of > 500 mm, in particular to a filling level of >650 mm. The filling level should be at least >30%, preferably 50% of the maximum filling level, in particular 70% of the maximum filling level. This has the advantage that the bubbler may be flooded at a throughflow rate of >30 l/min, preferably stably at 35 l/min or higher. This allows the process time and the process completion speed to be considerably shortened and the systems to have a higher productivity than would be achievable without automatic bubbler filling.

Experiments have shown that at flow rates of 35 l/min a stable process gas supply may be sustained over a lengthy period. At flow rates greater than 40 l/min, a drop in the flow quantity will develop over a longer period in the event that the bubbler pressure drops to below 250 mbar. With higher flow rates, a drop in the flow quantities will already develop at higher bubbler pressures. It is therefore recommended when flow rates greater than 35 l/m and preferably greater than 40 l/min are required to use two parallel bubblers and/or to use a process gas intermediate reservoir, described below, to preserve a stable and high process gas flow rate over a longer period.

The filling device may be advantageously used to fill two or more bubblers, in order to achieve an increase in the process gas concentration or to control the productivity of the system.

The filling device may nevertheless also be used in a filling system of an alternative process gas enrichment unit that operates comparably to a bubbler, to prevent oxygen from entering the system.

Furthermore, it is advantageously conceivable that a process gas storage tank that can store process gas enriched by the bubbler is provided downstream of the bubbler, i.e. between the bubbler and the process chamber. As a result, process gas can be enriched by the bubbler and initially stored in a higher quantity inside the process gas storage tank. With the gas stored in the process gas storage tank, a process chamber can be flooded to match needs at a considerably higher flooding rate than with the process gas flow that the bubbler can deliver. Hence a process gas enriched by the bubbler with a relatively low bubbler rate may be stored in the process gas storage tank and abruptly released into a process chamber to achieve a higher flooding rate. This results in the possibility of a productivity improvement or process gas concentration increase, alternatively or additionally to the parallel operation of several bubblers.

DRAWING

Further advantages emerge from the following drawing description. The drawing shows examples of the invention. The drawing, the description and the claims contain many features in combination. The person skilled in the art will expediently also consider the features individually and combine them into meaningful further combinations.

In the figures:

Fig. 1 shows a schematic illustration of an embodiment of a filling device or of a filling system in an initial state;

Figs 2A - 2D show the embodiment of Fig. 1, in each case at a different time during an advantageous method for operating the filling device, and

Fig. 3 shows the embodiment of Fig. 1 during initial commissioning;

Fig. 4 shows a further embodiment of a filling device;

Identical elements are denoted with the same reference signs in the figures. The figures merely show examples and should not be understood as being limiting.

Figure 1 shows a simplified schematic illustration of an advantageous filling device 10 for filling a bubbler 12. The filling device 10 is designed to fill the bubbler 12 with a process fluid 14 at regular intervals and/or continuously to ensure its operation for the intended purpose. The bubbler 12 is in the present case installable or installed in a soldering or sintering system, not shown for reasons of clarity, and forms together with the filling device 10 a filling system 16 for the soldering or sintering system.

To that extent, the filling device 10 and the bubbler 12 or filling system 16 thus formed are in the present case installed in the soldering or sintering system during operation for the intended purpose.

The bubbler 12 is used to or is designed to mix process fluid 14 with a process gas and to supply the gaseous process mixture thereby formed via a bubbler outlet 18 to the soldering or sintering system, more precisely a process chamber of the system, usually a vacuum chamber. The process fluid 14 is in the present case formic acid HCOOH, and the process gas is nitrogen N2. The purge gas process mixture formed from process fluid 14 and a process gas introducible via a bubbler gas supply 40, as a rule with a formic acid concentration of between 0.5% and 1.5%, is used to reduce oxide layers on workpieces, in particular semiconductor components to be processed in the soldering or sintering system, in order to ensure oxide-free further processing of said workpieces.

To replenish the process fluid 14, continuously consumed during the course of operation of the bubbler 12 for the intended purpose, the filling device 10 is provided, by means of which a steady supply of process fluid 14 for the bubbler 12 can be assured.

The filling device 10 has in the present case a fluid reservoir 20 and a refilling reservoir 22 fluidically upstream of the fluid reservoir 20 and couplable thereto, wherein the process fluid 14 is suppliable to the bubbler 12 via the reservoirs 20, 22 starting from a fluid source 24.

For supplying the process fluid 14 to the bubbler 12, the latter is fluidically couplable to the fluid reservoir 20 via a switchable filling valve 26 or is fluidically coupled when the filling valve 26 is opened. The filling valve 26 may be an electric motor-powered, electromagnetic and/or pneumatically controllable valve, in particular a bellows valve. The filling valve 26 is in the present case controllable in automated manner such that the bubbler 12 is automatically and continuously refillable with the process fluid 14.

The fluid reservoir 20 is in turn fluidically couplable to the refilling reservoir 22 via two valves, in the present case a supply valve 28 and a pressure equalizing valve 30, or is fluidically coupled when the valves 28, 30 are opened. In the present case, the supply valve 28 is designed as a fluid flow valve 28 and is used in its opened state to enable a fluid flow of the process fluid 14 out of the refilling reservoir 22 into the fluid reservoir 20. The supply valve 28 is preferably designed controllable magnetically and/or pneumatically, in particular additionally in automated manner, in particular as a bellows valve. The pressure equalizing valve 30 is used to or is designed to enable in its opened state a gas pressure equalization between the fluid reservoir 20 and the refilling reservoir 22. The pressure equalizing valve is preferably designed controllable magnetically and/or pneumatically, in particular additionally in automated manner, in particular as a bellows valve or non-return valve.

In the present case, the fluid reservoir 20 and the refilling reservoir 22 are designed as closed and pressure-tight containers. As shown schematically in Figure 1, it is furthermore provided that the refilling reservoir 22 fluidically upstream of the fluid reservoir 20 is arranged higher relative to the ground surface than the fluid reservoir 20, and is thus above the fluid reservoir 20 when viewed spatially. This ensures that the process fluid 14 can flow from the refilling reservoir 22 into the fluid reservoir 20 by means of gravity when the supply valve 28 and/or the fluid flow valve 28 are opened. Additionally or alternatively, it may be provided that the process fluid 14 is actively conveyed by expending energy, for example by a pumping device, from the refilling reservoir 22 into the fluid reservoir 20.

Furthermore, in the present case the fluid reservoir 20 and the refilling reservoir 22 each have

a level sensor 32, shown schematically in Figure 1 for monitoring the currently prevailing levels of process fluid 14 in the respective reservoirs 20, 22, i.e. the quantity of process fluid 14 present in the respective container.

While the fluid reservoir 20 or the container forming the fluid reservoir 20 is preferably always closed and designed pressure-tight, it may be provided that the refilling reservoir 22 or the container forming the refilling reservoir 22 is designed optionally openable, such that the refilling reservoir 22 can be filled with the process fluid 14 for example by simply removing a cover closing the container.

In the present case, it is provided that the refilling reservoir 22 or container is also closed and designed pressure-tight. To fill the refilling reservoir 22 with the process fluid 14, the refilling reservoir 22 has a fluid connection with a fluid refilling valve 34, by means of which the refilling reservoir 22 is fluidically couplable to the fluid source 24 or is coupled when the fluid refilling valve 34 is opened. The fluid refilling valve 34 is preferably designed controllable, in particular in automated manner, in particular magnetically and/or pneumatically, for supplying the process fluid 14.

Furthermore, the refilling reservoir 22 has a positive pressure valve 36 relieving a positive pressure prevailing in the refilling reservoir 22 under certain circumstances. By relieving the positive pressure as needed, it can be ensured that the refilling reservoir 22 is continuously or at least whenever required at the normal pressure level, such that it can be filled with process fluid 14 without a counter-acting positive pressure having to be actively overcome by expending energy, for example by pumping.

Also, the filling device 10 or filling system 16 comprises a control device, in this case not shown for reasons of clarity, which is designed to control the filling device 10 with respect to the filling of the reservoirs 20, 22 and of the bubbler 12 with the process fluid 14. Control includes in the present case in particular an opening and closing of the valves of the filling device 10 or of the filling system 16, at least of the filling valve 26, of the supply valve 28, of the pressure equalizing valve 30 and of the fluid refilling valve 34, and optionally of the positive pressure valve 36. The control device is configured to provide a controllable process fluid supply at least from the fluid source 24 to the refilling reservoir 22 and from there to the fluid reservoir 20, and preferably also from the fluid reservoir 20 to the bubbler 12.

As already explained at the outset, the process fluid 14 mixed with the process gas supplied by the bubbler gas supply 40 is used to remove oxide layers from the workpieces processed in the soldering or sintering system. For this it is essential that there is no oxygen whatsoever in the process atmosphere, and thus the process chamber of the system is oxygen-free. To ensure the absence of oxygen, it is advantageous that the mixture of process gas and process fluid 14 is supplied already oxygen-free to the system via the bubbler outlet 18.

To ensure in this respect oxygen-free filling of the bubbler 12 with the process fluid 14 and hence an oxygen-free supply of the process mixture to the system, the filling device 10 is designed such that the fluid reservoir 20 and the refilling reservoir 22 are atmospherically decouplable by means of a siphon effect.

For siphon-effect atmospheric decoupling, it is provided that a defined residual amount of process fluid 14 always remains in the refilling reservoir 22, which is assured in particular by the continuous monitoring of the current level by means of the level sensor 32. The continued presence of the defined residual amount of process fluid 14 creates a siphon effect by means of the gas barrier effect of this residual amount of process fluid when the supply valve 28 is opened, which ensures that the process fluid 14 is always controllably supplied oxygen-free from the refilling reservoir 22 to the fluid reservoir 20, and the fluid reservoir 20 always remains oxygen-free.

That the fluid reservoir 20 is always oxygen-free means in turn that the bubbler 12 always remains oxygen-free during filling with the process fluid 14, so that the ultimate effect is that the process mixture of the system is also suppliable oxygen-free.

Due to the previously mentioned arrangement of the refilling reservoir 22 fluidically upstream of the fluid reservoir 20, and due to the design and control of the supply valve 28 and pressure equalizing valve 30 in conjunction with the assured continuous presence of the defined residual amount of process fluid 14 in the refilling reservoir 22, the siphon-effect atmospheric decoupling can be assured (structurally).

The following is now intended to explain, based on Figures 2A to 2D, an advantageous method for operating the filling device 10 or filling system 16. To that end, Figures 2A to 2D each show

the filling device 10 or filling system 16 previously explained on the basis of Figure 1 at a different point in time during the method.

The method begins preferably at a first state shown in Figure 2A, in which, as is shown clearly in Figure 2A, only a very small quantity of process fluid 14 is still present in the fluid reservoir 20 and refilling reservoir 22. The presence of a minimum quantity of process fluid 14 and the dropping of the level below a predetermined first threshold value (fluid reservoir 20) or second threshold value (refilling reservoir 22) is detected by the respective level sensor 32 in conjunction with the control device, and refilling with the process fluid 14 is initiated as a result.

To that end, the fluid refilling valve 34 is opened, as shown in Figure 2A, and as a result process fluid 14, as shown in Figure 2A by corresponding fluid droplets, is refilled from the fluid source 24 into the refilling reservoir 22. Replenishment from the fluid source 24 continues until a defined fluid level, shown in Figure 2A by a dashed line, has been reached in the refilling reservoir 22. Reaching of the defined fluid level is detected by the level sensor 32 of the refilling reservoir 22.

Once the defined fluid level is reached, the pressure equalizing valve 30 is opened in a second step to ensure pressure equalization between the fluid reservoir 20 under positive pressure and the refilling reservoir 22 at a lower pressure level. Opening of the pressure equalizing valve 30, and the pressure equalization achieved as a result, are shown schematically in Figure 2A by a pale background for the pressure equalizing valve 30 and by a number of gas bubbles 38. The positive pressure flowing into the refilling reservoir 22 can then escape from the refilling reservoir 22 into the atmosphere via the positive pressure valve 36.

Figure 2B shows the filling device 10 or filling system 16 now in a second state, succeeding the first state in the course of the method. After pressure equalization, the supply valve 28 to the fluid reservoir 20 is opened in a third step, as is shown in Figure 2B by a pale background for the supply valve 28. This allows the process fluid 14, as shown in Figure 2B by corresponding fluid droplets, to flow out of the refilling reservoir 22 into the fluid reservoir 20 or to be supplied to the latter. The supply valve 28 remains opened until the filling level of the refilling reservoir 22 has dropped to the defined minimum quantity of process fluid 14 for ensuring the siphon effect, which is detected by the level sensor 32.

Alternatively, the supply valve 28 remains opened until so much process fluid 14 has flowed into the fluid reservoir 20 that an intended fluid level in the fluid reservoir 20 has been reached,

as indicated schematically in Figure 2B by a dashed line and by an arrow, wherein it goes without saying that the defined minimum quantity of process fluid 14 remaining in the refilling reservoir 22 does not drop below that required to ensure the siphon effect, and is monitored by the level sensor 32. The reaching of the intended fluid level in the fluid reservoir 20 is in turn detected by the level sensor 32 of the fluid reservoir 20.

To that extent, it is assured at all times that the minimum quantity of process fluid 14 always remains in the refilling reservoir 22 such that the latter is atmospherically decoupled by a siphon effect from the fluid reservoir and the process fluid is supplied exclusively oxygen-free to the fluid reservoir 20.

After filling of the fluid reservoir 20, the supply valve 28 and the pressure equalizing valve 30 are closed in a fourth step. This third state of the filling device 10 or filling system 16 is shown in Figure 2C. The closing of the supply valve 28 and the pressure equalizing valve 30 is indicated schematically here by a dark background for the two valves 28, 30.

After closing of the supply valve 28 and the pressure equalizing valve 30, the filling valve 26 between the fluid reservoir 20 and the bubbler 12 is opened in a fifth step, as is shown in Figure 2C by a pale background for the filling valve 26. This leads to a positive pressure equalization being performed between the pressures prevailing in the bubbler 12 and in the fluid reservoir 20 respectively, as is again indicated schematically in Figure 2C by corresponding gas bubbles 38.

Figure 2D shows the filling device 10 or filling system 16 now in a fourth state, succeeding the third state in the course of the method. As shown in Figure 2D, following the pressure equalization between the fluid reservoir 20 and the bubbler 12, a gas pressure in the bubbler 12 is reduced in a sixth step, while the filling valve 26 remains opened. This sixth step is performed preferably during non-activity of the bubbler 12, in particular in times during which no soldering or sintering process is in progress in the soldering or sintering system, i.e. in particular the workpiece or component currently being processed is being moved inside the system between process chambers. Opening of the filling valve 26 after completing the pressure equalization and pressure reduction in the bubbler 12 allows, as illustrated in Figure 2D by corresponding fluid droplets, the process fluid 14 to flow into the bubbler 12 or to be supplied to the latter. Additionally or alternatively, the process fluid 14 may (as assistance) be actively conveyed into the bubbler, for example by a pump. The filling valve 26 remains open until a fixed level of process fluid 14 is reached in turn inside the bubbler 12.

After a sufficient fluid level has been reached in the bubbler 12, the filling valve 26 is closed

again in a seventh step, and the positive pressure in the bubbler 12 is restored. Following this, the process fluid 14 mixed with the process gas can be supplied again, in accordance with the intended purpose, to the system via the bubbler outlet 18.

Figure 3 shows in conclusion the previously discussed filling device 10 or filling system 16 during a special state in which an initial filling of the filling device 10 or filling system 16, i.e. specifically of the refilling reservoir 22 and the fluid reservoir 20, is performed with the process fluid 14. During this initial filling, oxygen is present at least in the fluid reservoir 20, such that at this point in time the previously discussed advantageous siphon-effect atmospheric decoupling of the refilling reservoir 22 and the fluid reservoir 20 cannot be ensured.

To that extent, it is necessary, in a step zero which is timed before the steps one to seven previously discussed on the basis of Figures 2A to 2D, to remove the initially present oxygen at least from the bubbler 12 and the fluid reservoir 20. In this step zero or the special state shown in Figure 3, initial commissioning, maintenance or initial filling of the filling device 10 with process fluid 14 is performed. Furthermore, oxygen removal may be performed if required, for example whenever the defined residual amount of process fluid 14 present in the refilling reservoir 22 inadvertently drops below the required amount in such a way that the siphon effect is no longer assured.

During step zero, a respective gas pressure in the bubbler 12 and in the fluid reservoir 20 is reduced, preferably within 10 seconds, to below 10 mbar. All valves between the refilling reservoir 22, the fluid reservoir 20 and the bubbler 12, i.e. in the present case the filling valve 26, the supply valve 28 and the pressure equalizing valve 30, are then opened, as illustrated in Figure 3 by a pale background for the corresponding valves 26, 28, 30.

Then the bubbler 12 is subjected to pressure and also purged for at least for 2 minutes with the process gas introduced through the bubbler gas supply 40. Purging with the process gas, in the present case nitrogen, is shown in Figure 3 as an example by an arrow and by corresponding gas bubbles 38, introduced by a bubbler gas supply 40. The process gas introduced into the bubbler 12 via the bubbler gas supply 40 flows through the opened valves 26, 28, 30 from the bubbler 12 into the fluid reservoir 20 and from there into the refilling reservoir 22, whereupon it escapes into the atmosphere via the positive pressure valve 36.

Due to the fact that the process gas is introduced under positive pressure into the bubbler 12 via the bubbler gas supply 40 and thus logically flows under pressure through the two reservoirs 20, 22, the oxygen present in the system, in particular in the fluid reservoir 20, is gradually forced out of the corresponding containers by the process gas supplied by the

bubbler gas supply 40 and pressed out into the atmosphere via the positive pressure valve 36.

At the same time, during purging, the process fluid 14 from the fluid source 24 is introduced into the refilling reservoir 22 until the intended minimum filling level of process fluid 14 shown in Figure 3 by a dashed line, i.e. the defined residual amount, has been reached. As a result of the introduction of the process gas with positive pressure during purging, a flow of the process fluid 14 out of the refilling reservoir 22 into the fluid reservoir 20 via the supply valve 28 is dependably prevented, as the gas pressure counteracts the inflow of the process fluid 14. After a certain point in time, the fixed residual or minimum quantity of process fluid 14 in the refilling reservoir 22 is thus reached again, such that the siphon effect for atmospheric decoupling is again assured. In the course of further purging, the oxygen present in the fluid reservoir 20 is then continuously forced out of it, wherein any new ingress of oxygen into the fluid reservoir 20 is furthermore dependably prevented by the siphon effect, i.e. by the process fluid 14 now present in the refilling reservoir 22.

After a sufficient minimum time in which the system has been purged and as a result the oxygen present has been forced out, all valves between the refilling reservoir 22, the fluid reservoir 20 and the bubbler 12, in particular the supply valve 28, the pressure equalizing valve 30 and the filling valve 26, are closed again, such that the absence of oxygen in the system is restored and the intended operation, as previously explained on the basis of Figures 2A to 2D, can be resumed.

As is made clear by the preceding explanation, it is advantageously ensured by the advantageous filling device 10 or filling system 16 discussed in the present case, in conjunction with the method discussed for operation, that no interruption of the operation of the bubbler 12 and/or of the soldering or sintering system for their intended purposes is necessary for replenishment of the bubbler 12 and of the fluid reservoir 20, since the process fluid 14 is always supplied oxygen-free to the fluid reservoir 20 and hence to the bubbler 12.

By provision of the refilling reservoir 22 in conjunction with the siphon-effect atmospheric decoupling, a continuous oxygen-free filling of the fluid reservoir 20 and of the bubbler 12 may be advantageously assured. The fluid reservoir 20 is thus preferably filled oxygen-free with process fluid 14 from the refilling reservoir 22, while the bubbler 12 is operated for its intended purpose with the process fluid 14 still present therein and the process mixture is supplied to

the system. During pause times of the bubbler 12, i.e. in particular at times in which the currently processed workpiece is being moved inside the system, the amount of process fluid 14 is in turn preferably replenished in the bubbler 12 oxygen-free from the fluid reservoir 20.

Hence there is at no time any interruption needed in the operation of the bubbler 12 or of the soldering or sintering system for their intended purposes, so that the process efficiency of the system is considerably improved by the avoidance of downtimes.

Fig. 4 shows a further embodiment based on the embodiment of the filling device with bubbler in Fig. 3. This differs from the embodiment shown in Fig. 3 in that two bubblers 12 can be filled individually and independently by the filling device 10. It is furthermore conceivable to couple more than two bubblers 12 to the fluid reservoir 20, controllably in each case using a filling valve 26, such that productivity and efficiency in the provision of process gas inside the system can be considerably increased.

The form of the refilling reservoir and the filling reservoir may be adaptable in their positions and shapes to specific system requirements. Their positions relative to one another, in particular their height difference, may also be individualized, and the refilling reservoir and the filling reservoirs and possibly also the bubblers may be arranged horizontally adjacent and possibly at the same height, wherein a fluid flow is settable using the relative height difference in the liquid levels via the valves 26, 28 and 30.

The filling device in accordance with the invention consists – in other words – of a replenishment container, an intermediate container and the bubbler connected thereto, which are connected to one another. A reduction fluid such as formic acid, methanoic acid or citric acid is filled into the replenishment container via the replenishment side (supply of media such as compressed air or nitrogen). The reduction fluid acts as a gas barrier and prevents oxygen from getting into the soldering or sintering system. If the level monitoring indicates that reduction fluid has to be replenished, the formic acid is passed from the replenishment container into the intermediate container. The intermediate container ensures pressure equalization. If required, the reduction fluid is transferred from the intermediate container into the bubbler(s), wherein reduction fluid is transferrable out of the replenishment container into the intermediate container independently of that. This operation is performed fully automatically and parallel without impairing the soldering process. This achieves the following advantages:

- Higher system availability (no downtimes due to replenishment or replacement of the bubbler)

- Proven and very high process quality
- Higher process reliability (due to oxygen-free filling)
- No acid handling in clean room
- Self-ventilating system

Reference numeral list

10 Filling device
12 Bubbler
14 Process fluid
16 Filling system
18 Bubbler outlet
20 Fluid reservoir
22 Refilling reservoir
24 Fluid source
26 Filling valve
28 Supply valve, fluid flow valve
30 Pressure equalizing valve
32 Level sensor
34 Fluid refilling valve
36 Positive pressure valve
38 Gas bubble
40 Bubbler gas supply

Claims

1. A filling device (10) for filling at least one bubbler (12), installable or installed in a soldering or sintering system, with a process fluid (14), in particular formic acid, methanoic acid (CH_2O_2) or citric acid, wherein the filling device (10) comprises a fluid reservoir (20), fluidically couplable or coupled to the at least one bubbler (12) by means of at least one filling valve (26), to which reservoir the process fluid (14) is controllably suppliable and which is designed to controllably fill the bubbler (12) with the process fluid (14), **characterized in** that the filling device (10) comprises at least one refilling reservoir (22) which is connected fluidically upstream of the fluid reservoir (20) and to which the process fluid (14) is suppliable starting from a fluid source (24); wherein the refilling reservoir (22) and the fluid reservoir (20) are controllably connectable by means of at least one supply valve (28); wherein the refilling reservoir (22) is atmospherically decoupled from the fluid reservoir (20) by a siphon effect when the supply valve (28) is opened, such that the process fluid (14) is always controllably suppliable oxygen-free from the refilling reservoir (22) to the fluid reservoir (20) via the at least one supply valve (28), and the fluid reservoir (20) always remains oxygen-free.

2. The filling device according to claim 1, **characterized in** that the refilling reservoir (22) and the fluid reservoir (20) are fluidically couplable or coupled by means of the supply valve (28), such that a gas pressure equalization between the fluid reservoir (20) and the refilling reservoir (22) is achievable by the supply valve (28).

3. The filling device according to claim 1, **characterized in** that at least one pressure equalizing valve (30) is provided between the refilling reservoir (22) and the fluid reservoir (20), wherein the supply valve (28), in particular designed as a bellows valve, is designed as a fluid flow valve (28) to permit a fluid flow, and the pressure equalizing valve (30), in particular designed as a bellows or non-return valve, is designed to permit gas pressure equalization.

4. The filling device according to any of the preceding claims, **characterized in** that the refilling reservoir (22) comprises a positive pressure valve (36) for relieving positive pressure, in particular designed as a non-return valve, and/or a fluid connection, in particular with a fluid refilling valve (34), for the supply, in particular controllable, of process fluid (14) from the fluid source (24) into the refilling reservoir (22).

5. The filling device according to any of the preceding claims, **characterized in** that at least the fluid reservoir (20), preferably also the refilling reservoir (22), is designed as a closed, preferably pressure-tight and in particular optionally openable container, wherein the refilling reservoir (22) is arranged higher than the fluid reservoir (20) relative to the ground surface, such that process fluid (14) is suppliable from the refilling reservoir (22) to the fluid reservoir (20) by means of gravity.

6. The filling device according to any of the preceding claims, **characterized in** that the refilling reservoir (22) and/or the fluid reservoir (20) has at least one level sensor (32).

7. The filling device according to any of the preceding claims, **characterized in** that at least the filling valve (26) is controllable in automated manner, such that the bubbler (12) is refillable automatically and/or continuously with process fluid (14) from the fluid reservoir (20).

8. The filling device according to any of the preceding claims, **characterized in** that a fluid refilling valve (34) for the controllable supply of process fluid (14) from the fluid source (24) into the refilling reservoir (22) is arranged between the refilling reservoir (22) and the fluid source (24).

9. The filling device according to any of the preceding claims, **characterized in** that a control device is comprised which is connected to the filling valve (26) and at least to the supply valve (28), preferably also to the level sensor (32) of the fluid reservoir (20) and/or to the level sensor (32) of the refilling reservoir (22) and/or to the pressure equalizing valve (30), and the control device is configured to provide a controllable process fluid supply from the fluid reservoir (20) into the bubbler (12) and from the refilling reservoir (22) into the fluid reservoir (20).

10. A bubbler system (16) for a soldering or sintering system, having a bubbler (12) for supplying a process fluid (14), in particular formic acid, mixed with a process gas, in particular nitrogen, into at least one process chamber of the soldering or sintering system, and having a filling device (10) for filling the bubbler (12) with the process fluid (14), **characterized by** a filling device (10) according to any of claims 1 to 9.

11. A soldering or sintering system with a bubbler system (16) for supplying a process fluid (14), in particular formic acid, mixed with a process gas, in particular nitrogen, into at least one process chamber of the soldering or sintering system, **characterized by** a bubbler system (16) according to claim 10.

12. A method for operating a filling device (10), in particular the filling device (10) according to any of claims 1 to 9, wherein by means of the filling device (10) at least one bubbler (12) installable or installed in a soldering or sintering system is controllably filled with a process fluid (14), wherein the bubbler (12) is fluidically coupled to a fluid reservoir (20) of the filling device (10) by means of at least one filling valve (26), to which reservoir the process fluid (14) is supplied, **characterized in** that a refilling reservoir (22) of the filling device (10) is connected fluidically upstream of the fluid reservoir (20), to which reservoir the process fluid (14) is supplied starting from a fluid source (24); wherein the refilling reservoir (22) and the fluid reservoir (20) are controllably decoupled atmospherically by a siphon effect by means of at least one supply valve (28), such that the process fluid (14) is always controllably supplied oxygen-free from the refilling reservoir (22) to the fluid reservoir (20), and the fluid reservoir (20) is always kept oxygen-free.

13. The method according to claim 12, **characterized in** that the bubbler (12) is controllably refilled from the oxygen-free fluid reservoir (20) with the oxygen-free process fluid (14) present in said fluid reservoir (20) via the filling valve (26), to match demand and/or continuously, preferably in times in which no soldering or sintering process is in progress in the soldering or sintering system, in particular during transfer times of workpieces inside the soldering or sintering system.

14. The method according to claim 13, **characterized in** that fluidically independently of refilling of the bubbler (12), the fluid reservoir (20) is filled oxygen-free with the process fluid (14) by the refilling reservoir (22), without interrupting the operation of the bubbler (12), during operation of the soldering or sintering system for the intended purpose, wherein the fluid reservoir (20) is preferably filled with the process fluid (14) while the bubbler (12) is being operated for the intended purpose.

15. The method according to any of claims 12 to 14, **characterized in** that for the siphon-effect atmospheric decoupling, the fluid reservoir (20) and the refilling reservoir (22) are coupled via the supply valve (28), in particular designed as a bellows valve, and via a pressure equalizing valve (30), in particular designed as a bellows valve, wherein the process fluid (14) is controllably supplied from the refilling reservoir (22) to the fluid reservoir (20) via the supply valve (28), and a gas pressure between the refilling reservoir (22) and the fluid reservoir (20) is equalized using the pressure equalizing valve (30), wherein a defined residual amount of process fluid (14) always remains inside the refilling reservoir (22), such that any ingress of oxygen into the fluid reservoir (20) is prevented.

16. The method according to any of claims 12 to 15, **characterized in** that the process fluid (14) is supplied from the refilling reservoir (22) to the fluid reservoir (20) and/or from the fluid reservoir (20) to the bubbler (12) by means of gravity and/or by means of positive pressure.

17. The method according to any of claims 12 to 16, **characterized in** that a level of the process fluid (14) present in the refilling reservoir (22) and/or in the fluid reservoir (20) is detected by means of a level sensor (32), wherein a controllable supply of process fluid (14) from the refilling reservoir (22) into the fluid reservoir (20) is triggered in the event that the process fluid level in the fluid reservoir (20) drops below a predeterminable first threshold value, and wherein a controllable supply of process fluid (14) from the fluid source (24) into the refilling reservoir (22), or at least an instruction to the operator to refill the refilling reservoir (22) from the fluid source (24), is triggered in the event that the process fluid level in the refilling reservoir (22) drops below a predeterminable second threshold value.

18. The method according to any of claims 12 to 17, **characterized in** that during ongoing operation of the soldering or sintering system the following steps are performed for filling the bubbler (12):

    a) in a first step, the process fluid (14) is filled from the fluid source (24) into the refilling reservoir (22);

b) in a second step, a pressure equalizing valve (30) is opened to equalize the pressure between the fluid reservoir (20) under positive pressure and the refilling reservoir (22), wherein a positive pressure can preferably escape into the atmosphere via a positive pressure valve (36) of the refilling reservoir (22);

c) in a third step, the supply valve (28) is opened to supply the process fluid (14) from the refilling reservoir (22) to the fluid reservoir (20);

d) in a fourth step, the supply valve (28) and the pressure equalizing valve (30) are closed;

e) in a fifth step, the filling valve (26) between the fluid reservoir (20) and the bubbler (12) is opened in order to perform a pressure equalization between the pressures prevailing in the bubbler (12) and in the fluid reservoir (20) respectively;

f) in a sixth step, preferably during non-activity of the bubbler (12), preferably in times in which no soldering or sintering process is in progress in the soldering or sintering system, specifically during transfer times of workpieces inside the soldering or sintering system, a gas pressure in the bubbler (12) is reduced and the filling valve (26) is opened to supply process fluid (14) from the fluid reservoir into (20) the bubbler (12);

g) in a seventh step, a positive pressure is restored in the bubbler (12) and the filling valve (26) is closed again.

19. The method according to any of claims 12 to 18, **characterized in** that for the removal of oxygen from the filling device, in particular during initial commissioning, for maintenance purposes, and/or for the initial filling of the filling device with process fluid (14), and preferably repeatedly when a process fluid minimum of preferably 2.5 litres is reached, the following steps are performed one after the other:

I. A respective gas pressure in the bubbler (12) is reduced, preferably within 10s, to below 10 mbar;

II. A gas pressure in the fluid reservoir (20) is reduced, preferably within 10s, to below 10 mbar;

III. All valves between the refilling reservoir (22), the fluid reservoir (20) and the bubbler (12) are opened;

IV. The bubbler (12) is subjected to pressure while being purged with a process gas for at least 2 min, wherein a positive pressure escapes via a positive pressure valve (36) of the refilling reservoir (22);

V. All valves between the refilling reservoir (22), the fluid reservoir (20) and the bubbler (12) are closed.

20. The method according to any of claims 12 to 19, **characterized in** that the bubbler (12) is filled to a predeterminable filling level, preferably to a filling level of > 500 mm, in particular to a filling level of >650 mm.