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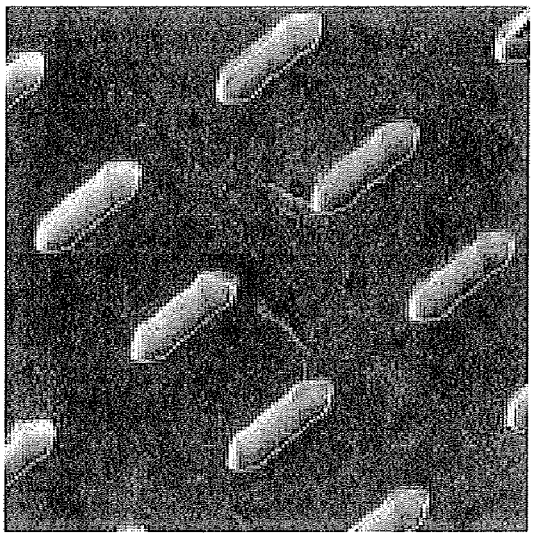
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(54) Title: A VENTILATION ELEMENT FOR A METAL-AIR BATTERY, RELATED DEVICES AND MANUFACTURING METHODS

Fig. 3



(57) Abstract: The present invention is related to the ventilation of a metal-air battery for a hearing device. The invention proposes a ventilation element (1) comprising a membrane (2) with at least one vent opening (3) of predetermined geometrical dimension for providing ventilation between the interior of the metal-air battery and its surroundings. Thereby the membrane (2) is obtained by depositing material, wherein the at least one vent opening (3) is a recess clearance in the material.

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A VENTILATION ELEMENT FOR A METAL-AIR BATTERY, RELATED DEVICES AND MANUFACTURING METHODS

TECHNICAL FIELD OF THE INVENTION

The present invention is related to the design of a metal-air battery for a hearing device. In particular, the invention involves a ventilation element, related devices comprising such a ventilation element, for example a ventilation assembly, a metal-air battery arrangement or a hearing device as well as methods for manufacturing such a ventilation element or the related devices. The ventilation element is also called a venting element, a gas diffusion element, an air supply or an air supply element and the ventilation assembly is also called an air supply assembly or gas diffusion assembly.

BACKGROUND OF THE INVENTION

Metal-air batteries are often used as power supply in a hearing device, because this type of battery provides very high capacity for extended periods of operation time. In the particular case of extended wear hearing aids the time of operation can be typically in the range of several weeks or months. To achieve this, such hearing instruments are optimized for very low power consumption in the range of

micro-Ampères. Thus, the battery must also be adjusted to deliver a very low current - usually between 50uA to 300uA.

A metal-air battery requires oxygen from its surroundings in order to generate electrical power. The inflow of oxygen/air needs to be limited in order to deliver just enough current to guarantee a reliable operation of the hearing aid but prevent fast self-discharge of the battery when not in use. Equally important is the reduction of moisture exchange, which could cause flooding or drying out of the battery to achieve a stable power supply over the extended period of operation. Consequently, metal-air batteries are often kept in a gas impermeable housing with a specifically designed vent opening time. The vent opening is designed to provide a well-defined flow of air from the surroundings into the interior of the metal-air battery.

For example, WO 2005/0723383 A2 discloses a metal-air battery with a hole as a vent opening. The hole is drilled by a laser in order to obtain an inner diameter in the range of about 10 to 15 microns. The limitation of this approach is the repeatability of and the tolerances necessary to provide reproducible results.

An alternative approach is described in US 07379555 B2 where the gas diffusion is controlled by the porosity of a porous polymer membrane. The polymer membrane (e.g. PTFE) is partially compressed (coined) in order to further reduce gas diffusion. This approach has the disadvantage, that

manufacturing tolerances in material thickness and porosity can strongly influence the performance of the system.

SUMMARY OF THE INVENTION

The present invention has the objective to propose an improved ventilation, also called air supply, for a metal-air battery of a hearing device, further devices comprising such a ventilation element, for example a ventilation assembly, a metal-air battery arrangement or a hearing device, as well as improved methods for manufacturing such devices.

This objective is reached by a ventilation element comprising the features specified in claim 1. Further embodiments of the ventilation element as well as a method for manufacturing such a ventilation element, a ventilation assembly, a method for manufacturing the ventilation assembly, a metal-air battery arrangement and a hearing device are specified in the further claims.

Under the term "hearing device" a device is understood, which is worn in or adjacent to the user's ear with the objective to improve the user's acoustical perception. In particular, the term "hearing device" refers to:

- a hearing aid for improving the perception of a hearing impaired user towards the hearing perception of a user with normal hearing ability,

- a hearing protection for attenuating or baring acoustic signals from being perceived by the user, or
- a communication device, in particular to be used by a user with normal hearing ability, for assisting the hearing perception under difficult acoustical circumstances, for example in a noisy environment.

With respect to any application area, a hearing device may be applied behind the ear (BTE), in the ear (ITE), completely in the ear canal (CIC). In the case where a CIC device is left in the ear canal for several weeks or months, such a hearing device is generally regarded as an extended wear device. Further, the term "hearing device" also embraces devices being related to the hearing device such as a remote control or a remote amplifier.

The invention proposes a ventilation element for a metal-air battery, the ventilation element comprising a membrane with at least one vent opening of predetermined geometrical dimension for providing ventilation between the interior of the metal-air battery and its surroundings. Thereby the membrane is obtained by depositing material, i.e. a deposition of material, wherein the at least one vent opening is a recess clearance in the material. This enables a particular precise structure of the at least one vent opening, which, in turn, allows maintaining a suitable battery voltage when the hearing aid is operated in an ear canal of a user over an extended period of time.

The term "ventilation" includes an exchange of gas, in particular air, more particular oxygen for the metal-air battery as well as moisture. The exchange of moisture, i.e. water contained in the air, is needed to provide an adequate humidity to the electrolyte of the metal-air battery. Further the term "membrane" as used throughout this description and the claims refers to a layer or a sheet of material.

The exchange of gas at a metal-air battery is mainly accomplished by diffusion. Therefore the ventilation element serves as a gas diffusion control element or a diffusivity limiting membrane (DLM) or a gas diffusion membrane (GDM). In effect, the ventilation element is a choke or a barrier to the exchange of gas and a battery comprising such a ventilation element is also called a limited or a choked metal-air battery.

The ventilation element according to the invention comprises a precisely and/or fine structured vent opening. In particular, this structure is determined by a precise shape and/or a precise geometrical dimension, for example by a precisely round-shaped hole with a well-defined diameter since the air flow is directly dependent on the open area of the vent opening. Such a structure provides for a precise control of the exchange of gas through the vent opening. Therefore, the precisely structured vent opening provides for a high quality of the ventilation element. This allows building high-quality batteries within narrow specifications.

In an embodiment of the invention, the membrane is a material deposition and the at least one vent opening is a recess clearance in this material deposition. Thereby, the material deposition is regarded as a structure that is obtained by a technical process of depositing material, similar to a coating obtained by a coating process. In the sense of the present invention, the material deposition is defined as a layer of a firmly interconnected shapeless material such as particles of a powder material or particles obtained by a sputtering process. According to this definition, neither the membrane nor the material deposition nor the structure obtained by depositing material necessarily includes a substrate or an underlying workpiece, onto which the shapeless material is applied.

Surprisingly, the vent opening of the ventilation element according to the invention is a highly precise structure with a very small design tolerance. Compared to laser drilling or coining of a PTFE membrane much narrower tolerances and better repeatability can be achieved. In an example, a tolerance in the range of one micron or 5% is achieved.

Further, the ventilation element according to the invention allows for large scale reproduction by simultaneously depositing material for a large number of ventilation elements on a single substrate and by separating the individual ventilation element afterwards. Thus, with the ventilation element according to the invention an efficient

manufacturing, in particular a high manufacturing throughput, can be achieved, which, in turn, allows for a significant reduction of the manufacturing costs.

In a further embodiment of the ventilation element according to the invention, the at least one vent opening has a clearance or an inner diameter of less or equal than 8 microns, in particular less or equal than 4 microns and further in particular less or equal than 3 microns. These dimensions effectively reduce the exchange of gas and/or limit the exchange of gas to diffusion processes, thus providing an extended battery life.

In a further embodiment of the ventilation element according to the invention, the ratio between the diameter and the depth of the at least one vent opening, i.e. the aspect ratio, is more than 6, in particular more than 8. This way, the exchange of gas is mainly accomplished by a diffusion process.

In a further embodiment of the ventilation element according to the invention, the membrane comprises multiple, in particular symmetrically, equally, array-like or circularly regularly distributed, vent openings. This way, the ventilation element is more robust against clogging by dust or debris. Further, the tolerance of the effective clearance is reduced since diameter variations are influencing the air flow in a highly non-linear way. Thus the diameter tolerances of each single vent opening are added linearly which allows the design of a more robust

multi-hole system allowing more diameter variation on each single vent opening compared to e.g. laser drilling one large hole that would need very tight dimensional control.

In a further embodiment of the ventilation element according to the invention, the at least one vent opening is substantially round-shaped, square-shaped, slit-shaped or shaped according to bended slits. Slit-shaped openings have the advantage that they are more robust against clogging by dust or debris.

In a further embodiment of the ventilation element according to the invention, the deposited material of the membrane is substantially gas impermeable. This way, the exchange of gas is precisely controlled by the vent opening and a bypass gas exchange through the membrane is reduced or completely avoided.

In a further embodiment of the ventilation element according to the invention, the deposited material is a single layered sheet, in particular a metal foil, and further in particular a nickel foil. The single layer allows for efficient manufacturing, because there is no need to assemble different components. Further, with the metal foil high mechanical resistance and impermeability with respect to gas, moisture or water vapor is achieved.

In a further embodiment of the ventilation element according to the invention, the membrane has a thickness of more or equal than 20 microns, in particular more or equal

than 50 microns. This provides high mechanical resistance and impermeability with respect to gas or moisture or water vapor.

In a further embodiment of the ventilation element according to the invention, the ventilation element is suitable for a metal-air battery of a hearing device, in particular for a zinc-air battery. This way the ventilation element allows achieving an extended wear.

A further embodiment of the invention, involves a ventilation assembly comprising a ventilation element according to the invention or any one of their embodiments and a mounting element with an opening for mounting the ventilation element. Thereby the border region of the opening is attached to the periphery of the membrane, so as to substantially extend the areal dimension of the membrane.

Further, the invention proposes a method for manufacturing a ventilation element for a metal-air battery, in particular for a battery of a hearing device, in particular a zinc-air battery, the ventilation element comprising a membrane with at least one vent opening for providing ventilation between the interior of the metal-air battery and its surroundings, the method comprising the steps of:

- providing a substrate with a masking element that corresponds to the geometrical dimension, in particular to the negative, of the at least one vent opening to be included into the membrane;

- depositing material on the substrate to build the membrane while leaving open a recess clearance in the material as determined by the masking element;
- removing the masking element and at least partly the substrate from the membrane to obtain the ventilation element comprising the membrane with the at least one vent opening as determined by the recess clearance.

This method has the advantage that the membrane and the vent opening are built simultaneously in a single step. This is achieved by building the required geometric features by a manufacturing process, which is based on growing a layer of material into the desired shape. Therefore, a two step manufacturing process, namely to build up the membrane in a first step and to drill a hole into the membrane in a second step, is avoided. Consequently, manufacturing of the ventilation element is simplified.

The method according to the invention allows for efficient manufacturing of vent openings with highly precise and reproducible structures with small design tolerances. For example, tolerances in the range of 1 micron or 5% can be achieved. Further, the high repeatability allows for cost efficient manufacturing of high quality ventilation elements.

Further, a great number of ventilation elements can simultaneously be built on one single substrate, a so called wafer, in particular a silicon wafer. This allows

for an increased manufacturing throughput, which in turn leads to a significant reduction of the manufacturing costs.

Further, the method can be performed very consistently by well-known wafer processing technologies. This technology allows for a particular high precision and repeatability of the geometrical dimensions of the vent openings.

In a further embodiment of the method according to the invention, the masking element is obtained by lithography, in particular UV-light lithography, or, at least partly, by a LIGA or UV-LIGA process. UV-light has a wavelength shorter than visible light and longer than X-rays, which basically covers a range between 10 nm and 400 nm.

LIGA is an acronym for a manufacturing process to build three-dimensional microstructures. Such a process typically comprises the steps of lithography, electroplating and lapping. The lithography of the LIGA process can be accomplished by x-ray or UV-light. The latter case is called UV-LIGA process.

In a further embodiment of the method according to the invention, the material is deposited on the substrate by an electrochemical process or by electroforming of a metal, in particular nickel, or, at least partly, by a LIGA or UV-LIGA process. The material can be any material that can be deposited electrochemically, for example nickel, copper, silver or gold.

In a further embodiment of the method according to the invention, the ventilation element is suitable for a metal-air battery of a hearing device, in particular for a zinc-air battery. This provides a cost effective way for manufacturing a device with an extended wear.

Further, the invention proposes a ventilation assembly for a metal-air battery, in particular for a battery of a hearing device, in particular a zinc-air battery. This ventilation assembly comprises a ventilation element that comprises a membrane with at least one vent opening for providing ventilation between the interior of the metal-air battery and its surroundings. Thereby the ventilation assembly comprises a mounting element with an opening for mounting the ventilation element, wherein the border region of the opening being attached to the periphery of the membrane, so as to substantially extend the areal dimension of the membrane. Such a ventilation assembly is a compact, robust and cost effective to manufacture.

Further, the ventilation assembly according to the invention provides high flexibility for manufacturing processes, because the ventilation assembly can easily be adapted to all different kind of structures and/or requirements, for example for adapting a single sized or standardized type of ventilation element to a large variety of different battery sizes. In particular, the ventilation assembly allows building different batteries by cutting the periphery of the mounting element to the required geometry.

The mounting element and/or the membrane can be gas permeable, for example a porous membrane or substantially gas impermeable, for example a metal coated polymer or a metal foil. Also, the vent opening can be provided by, typically irregular, pores, for example the pores of a porous material such as a porous polymer.

Further, the ventilation assembly according to the invention allows for cost effective automated manufacturing of batteries with various geometries. Thereby the automated manufacturing is based on the ventilation assembly as a single core component with well defined and constant properties. The manufacturing of such a ventilation assembly can also be automated for high volume battery manufacturing.

In a further embodiment of the ventilation assembly according to the invention, the at least one vent opening is of predetermined geometrical dimension. Such a predetermined geometrical dimension, for example the specific diameter of a round-shaped hole, is specifically manufactured according to a predetermined design. Therefore, the predetermined geometrical dimension is basically independent from inherent material variations of the membrane such as homogeneity, thickness and material characteristics. Therefore, the predetermined geometrical dimension allows for a precise control of the exchange of gas.

The above mentioned advantages of the ventilation assembly, e.g. the high flexibility obtained by using the mounting element, are independent of the type or the manufacturing process of the vent opening. In an example, the vent opening is obtained by drilling, in particular by laser drilling.

In a further embodiment of the ventilation assembly according to the invention, the mounting element is substantially impermeable. This way, the exchange of gas through the mounting element is reduced or avoided.

In a further embodiment of the ventilation assembly according to the invention, the ventilation assembly, in particular the membrane and/or the mounting element, is substantially planar. This allows for convenient manufacturing and handling of the ventilation assembly or their components.

In a further embodiment of the ventilation assembly according to the invention, the ventilation element is a ventilation element according to the invention or any one of their embodiments. The advantages of this embodiment correspond to the previously mentioned advantages for the ventilation element according to the invention or any one of the embodiments thereof.

In a further embodiment of the ventilation assembly according to the invention, the mounting element comprises a first flange and the second flange, the first flange

abutting a first face of the membrane and the second flange abutting a second face of the membrane being opposite to the first face of the membrane.

Further, the invention proposes a method for manufacturing the ventilation assembly according to the previous embodiment, the method comprising the steps of:

- providing the mounting element in two parts, the first part comprising the first flange and a second part comprising the second flange;
- arranging the membrane of the ventilation element between the first part and the second part, such that the first flange abuts the first face of the membrane and the second flange abuts the second face of the membrane;
- assembling the two parts of the mounting element, in particular by laminating and/or compressing the parts against each other, to obtain the mounting element as a one-piece element.

With this method a particular flexible and cost-effective manufacturing of the ventilation assembly can be achieved.

In a further example of the method for manufacturing the ventilation assembly according to the previous embodiment comprises the step of heating at least one of the two parts.

Further, the invention proposes a metal-air battery arrangement, in particular for a hearing device, in particular a zinc-air battery arrangement, comprising a ventilation element according to the invention or any one

of the embodiments thereof or a ventilation assembly according to the invention or any one of the embodiments thereof.

Further, the invention proposes a hearing device, in particular a hearing aid or an extended wear device, comprising a metal-air battery arrangement according to the previous proposal. Thereby the extended wear device is a device with a time of operation in the range of two or more weeks or two or more months.

It is expressly pointed out that any combination of the above-mentioned embodiments, or combinations of combinations, is subject to a further combination. In particular the embodiments of the ventilation element are also embodiments of the ventilation assembly. Only those combinations are excluded that would result in a contradiction.

BRIEF DESCRIPTION OF THE DRAWINGS

Below, the present invention is described in more detail by means of exemplary embodiments and the included drawings. It is shown in:

Fig. 1 an illustration of a ventilation element 1, with a nickel foil 2 and with round-shaped holes 3 as a vent openings;

Fig. 2 an detailed illustration of a ventilation element according to Fig. 1, but with a substantially square-shaped hole 3;

Fig. 3 a illustration of a ventilation element according to Fig. 1, but with slit-shaped holes;

Fig. 4 an illustration of a ventilation element according to Fig. 1, but with bended slit-shaped holes;

Fig. 5 an illustration of a ventilation element according to Fig. 1, but with six round-shaped holes, equally and symmetrically distributed;

Fig. 6 a simplified illustration of a ventilation assembly 10 with a mounting element 14 and a ventilation element 11 similar to Fig. 1, but with six circularly distributed, round-shaped holes 13;

Fig. 7 a simplified illustration of a side view of the ventilation assembly according to Fig. 6, before being assembled; and

Fig. 8 a simplified illustration of the ventilation assembly according to Fig. 7, after being assembled.

BRIEF DESCRIPTION OF THE INVENTION

The described embodiments are meant as illustrating examples and shall not confine the invention.

Fig. 1 shows an illustration of a ventilation element 1 according to the invention. The ventilation element 1 comprises a nickel foil 2 as a membrane 2 and a plurality of holes 3 as vent openings.

The nickel foil 2 has a thickness of approx. 20 microns and is gas impermeable, in particular impermeable to air or oxygen and to moisture. The nickel foil 2 is obtained by depositing shapeless material, i.e. nickel particles, as described below. Thereby the shapeless material is deposited by an electrochemical process.

The holes 3 are round-shaped and array-like distributed on the nickel foil 2. Their diameter is approximately 2 microns. Thus, the aspect ratio of the holes 3, i.e. the ratio between the diameter and the depth, is approximately 10. As described below, the holes 3 are obtained as recess clearances in the nickel foil 2.

The initial phase before manufacturing the ventilation element 1 comprises the step of determining the diameter and distribution of holes 3, which are to be included into the nickel foil 2. This diameter and distribution is

determined to optimize the exchange of air between the interior of the battery and its surroundings.

In the following, the ventilation element 1 is manufactured according to the following steps:

a) providing a substrate with protrusions as masking elements. Thereby, the diameter and distribution of the protrusions correspond to the previously determined diameter and distribution of the holes 3 to be included.

b) depositing nickel on the substrate to build the nickel foil 2, while leaving open recess clearances in the nickel as determined by the protrusions.

c) removing the substrate and the protrusions from the nickel foil 2 to obtain the ventilation element 1 comprising the nickel foil 2 with the holes 3 as determined by the protrusions.

It is not necessary to completely remove all of the substrate as long as the influence of the remaining substrate on the exchange of air through the vent opening 3 is below a tolerable level.

Step a) is accomplished by lithography. Thereby, a photo-mask is positioned above the substrate, which previously has been treated with a layer of photo-sensitive resin. The

UV-light or the UV-radiation passes through the photo-mask and polymerises the resin. Then, the non-polymerised resin is dissolved through a development process. Finally, the protrusions remaining on the substrate are the negative of the holes 3 to be made, i.e. similar to stems rising from the substrate. This process step can also be regarded as part of a UV-LIGA process.

Step b) is carried out by electroforming, also called electro-plating. Thereby, the substrate with the protrusions is plunged into a galvanic bath. According to the electro-plating process, nickel is deposited directly on the exposed substrate but not on the protrusions. Consequently, the holes 3 are formed by the recess clearances occurring during the build-up of the nickel foil 2.

Step a) and b) are typically performed as steps in a LIGA or UV-LIGA process. However, LIGA processes may contain further process steps such as a lapping process, which are not required for producing the ventilation element 1.

The main problem with manufacturing the ventilation element 1 is the small diameter of the hole 3. Under the following simple assumptions:

- the required flow rate of the air at 20 psi is 0.016 ml/min and
- the length L of the hole 3 corresponding to a thickness of the nickel foil 2 of 20 microns,

the air flow through a single hole 3 in the nickel foil 2 is governed by the Hagen-Poiseulle equation:

$$Q = \frac{\pi \cdot (P_O - P_L) \cdot r_c^4}{8 \cdot \mu \cdot L}$$

wherein Q is the volume flow rate (cubic meters per second), r_c is the radius of the hole 3, P_0 is the pressure at the inlet of the hole 3, P_L is the pressure at the outlet of the hole 3 and μ is the air viscosity.

This means that the air flow is proportional to:

$$Q \approx \frac{r_c^4}{L}$$

Thus, the diameter of the hole 3 is very critical with regard to dimensional stability.

For a battery application in an extended wear hearing device the necessary flow rates are around 0.26 ml/s at an applied measurement pressure of 20 psi. Thus, a required size of the hole 3 in the nickel foil 2 with a thickness of 20 microns would be between 2 and 3 microns.

The above calculation is a crude approximation only and in reality the transport mechanism is diffusion controlled. However, the approximation shows the need for a very tightly controlled diameter of the hole 3.

Fig. 2 shows a detailed illustration of a ventilation element according to Fig. 1, but with a substantially square-shaped hole 3. The clearance, i.e. the diagonal distance is approx. 1.6 microns.

Fig. 3 shows an illustration of a ventilation element according to Fig. 1, but with slit-shaped holes.

Fig. 4 shows an illustration of a ventilation element according to Fig. 1, but with bended slit-shaped holes. The length of the slits is approx 20 microns and their width is approx. 2 microns.

Fig. 5 shows an illustration of a ventilation element according to Fig. 1, but with six round-shaped holes, equally and symmetrically distributed. The holes have a diameter of approx. 4 microns.

Fig. 6 shows a simplified illustration of a ventilation assembly 10 with an elliptically-shaped mounting element 14 and a round-shaped ventilation element 11, similar to the ventilation element 1 of Fig. 1. The ventilation element 11 also comprises a round-shaped nickel foil 12 as membrane, which corresponds to the nickel foil of Fig. 1. The round-shaped nickel foil 12 comprises six round-shaped holes 3, which as are circularly and coaxially distributed in the middle of the round-shaped nickel foil 12. These holes 3 define a hole-comprising area of the nickel foil 12.

The mounting element 14 comprises a round shaped opening that is larger than the hole-comprising area of the nickel foil 12. The mounting element 14 is attached with border region of its opening to the periphery of the nickel foil 12, so as to extend the areal dimension of the nickel foil 12. Consequently, the ventilation assembly 10 is substantially planar and the round-shaped periphery of the nickel foil 12 is substantially extended to the elliptically shaped periphery of the mounting element 14.

Fig. 7 shows a simplified illustration of a side view of the ventilation assembly according to Fig. 6, before being assembled.

The mounting element comprises two parts, the first part with a first flange 14a and a second part with the second flange 14b. In this example the material of the mounting element as well as of the flanges 14a and 14b is a porous polymer.

The ventilation assembly is manufactured in a first step by providing the mounting element in two parts, the first part comprising the first flange 14a and a second part comprising the second flange 14b. In a second step, the nickel foil is arranged between a first part and a second part, such that the first flange 14a abuts a first face of the nickel foil and the second flange 14b abuts a second face of the nickel foil, which is arranged opposite to the first face. In this example the nickel foil is arranged in the center of the opening of the mounting element, such

that the round-shaped nickel foil and the round-shaped opening of the mounting element are coaxial.

The ventilation assembly is completed by applying a pressure on the two parts of the mounting element (indicated by the numerous arrows in Fig. 7). The next step, concerning the final assembly of mounting element, is described in Fig. 8.

Fig. 8 shows a simplified illustration of the ventilation assembly according to Fig. 7, after being assembled. Thereby the beginning of the assembling, i.e. the applying of pressure on the two parts of the mounting element is described in Fig. 7. The connection between the two parts of the mounting element is accomplished by heating the two parts and compressing these parts against each other, to obtain the mounting element as a one-piece element. Consequently, the mounting element firmly holds the ventilation element coaxially at its periphery. A mounting element made from porous polymer is particularly suited for such an assembly.

CLAIMS

1. A ventilation element (1) for a metal-air battery, the ventilation element (1) comprising a membrane (2) with at least one vent opening (3) of predetermined geometrical dimension for providing ventilation between the interior of the metal-air battery and its surroundings, wherein the membrane (2) is obtained by depositing material, and wherein the at least one vent opening (3) is a recess clearance in the material.

2. The ventilation element (1) according to claim 1, wherein the at least one vent opening (3) has a clearance or an inner diameter of less or equal than 8 microns, in particular less or equal than 4 microns and further in particular less or equal than 3 microns.

3. The ventilation element (1) according to claims 1 or 2, wherein the membrane (2) comprises multiple, in particular symmetrically, equally, array-like or circularly regularly distributed, vent openings (3).

4. The ventilation element (1) according to any one of the previous claims, wherein the at least one vent opening (3) is substantially round-shaped, square-shaped, slit-shaped or shaped according to bended slits.

5. The ventilation element (1) according to any one of the previous claims, wherein the deposited material of the membrane (2) is substantially gas impermeable.

6. The ventilation element (1) according to any one of the previous claims, wherein the deposited material is a single layered sheet, in particular a metal foil, and further in particular a nickel foil.

7. The ventilation element (1) according to any one of the previous claims, wherein the membrane (2) has a thickness of more or equal than 20 microns, in particular more or equal than 50 microns.

8. The ventilation element (1) according to any one of the previous claims, wherein the ventilation element (1) is suitable for a metal-air battery of a hearing device, in particular for a zinc-air battery.

9. A ventilation assembly (10) comprising a ventilation element (1) according to any one of the previous claims and a mounting element (14) with an opening for mounting the ventilation element (1), the border region of the opening being attached to the periphery of the membrane (2), so as to substantially extend the areal dimension of the membrane (2).

10. A method for manufacturing a ventilation element (1) for a metal-air battery, the ventilation element (1) comprising a membrane (2) with least one vent opening

(3) for providing ventilation between the interior of the metal-air battery and its surroundings, the method comprising the steps of:

- providing a substrate with a masking element that corresponds to the geometrical dimension, in particular to the negative, of the at least one vent opening (3) to be included into the membrane (2);

- depositing material on the substrate to build the membrane (2) while leaving open a recess clearance in the material as determined by the masking element;

- removing the masking element and at least partly the substrate from the membrane (2) to obtain the ventilation element (1) comprising the membrane (2) with the at least one vent opening (3) as determined by the recess clearance.

11. The method according to claim 10, wherein the masking element is obtained by lithography, in particular UV-light lithography, or, at least partly, by a LIGA or UV-LIGA process.

12. The method according to claim 10 or 11, wherein the material is deposited on the substrate by an electrochemical process or by electroforming of a metal, in particular nickel, or, at least partly, by a LIGA or UV-LIGA process.

13. The method according to any one of the claims 10 to 12, wherein the ventilation element (1) is suitable for a metal-air battery of a hearing device, in particular for a zinc-air battery.

14. A ventilation assembly (10) for a metal-air battery, in particular for a battery of a hearing device, in particular a zinc-air battery, the ventilation assembly (10) comprising a ventilation element (1; 11) that comprises a membrane (2; 12) with at least one vent opening (3; 13) for providing ventilation between the interior of the metal-air battery and its surroundings, wherein the ventilation assembly (10) comprises a mounting element (14) with an opening for mounting the ventilation element (1; 11), the border region of the opening being attached to the periphery of the membrane (2; 12), so as to substantially extend the areal dimension of the membrane (2; 12).

15. A ventilation assembly (10) according to claim 14, wherein the at least one vent opening (3; 13) is of predetermined geometrical dimension.

16. A ventilation assembly (10) according to claim 14 or 15, wherein the ventilation element (1; 11) is a ventilation element (1; 11) according to any one of the claims 1 to 8.

17. The ventilation assembly (10) according to any one of claims 14 to 16, wherein the mounting element (14)

comprises a first flange (14a) and the second flange (14b), the first flange (14a) abutting a first face of the membrane (2; 12) and the second flange (14b) abutting a second face of the membrane (2; 12) being opposite to the first face of the membrane (2; 12).

18. A method for manufacturing the ventilation assembly (10) according to the previous claim, the method comprising the steps of:

- providing the mounting element (14) in two parts, the first part comprising the first flange (14a) and a second part comprising the second flange (14b);

- arranging the membrane (2; 12) of the ventilation element (1) between the first part and the second part, such that the first flange (14a) abuts the first face of the membrane (2; 12) and the second flange (14b) abuts the second face of the membrane (2; 12);

- assembling the two parts of the mounting element (14), in particular by laminating and/or compressing the parts against each other, to obtain the mounting element (14) as a one-piece element.

19. A metal-air battery arrangement, in particular for a hearing device, in particular a zinc-air battery arrangement, comprising a ventilation element (1) according to any one of the claims 1 to 8 or a

ventilation assembly (10) according to claim 9 or to any one of the claims 14 to 17.

20. A hearing device, in particular a hearing aid or an extended wear device, comprising a metal-air battery arrangement according to the previous claim.

Fig. 1

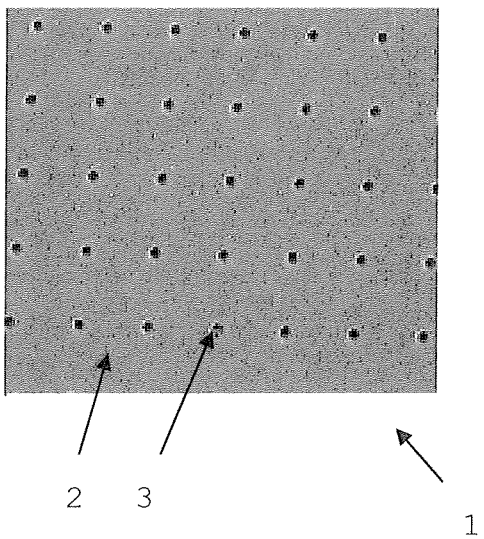


Fig. 2

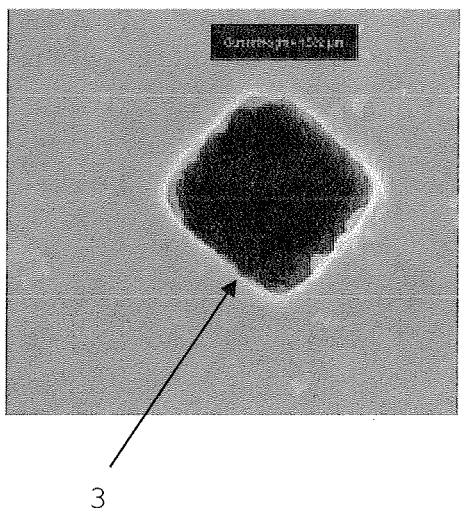


Fig. 3

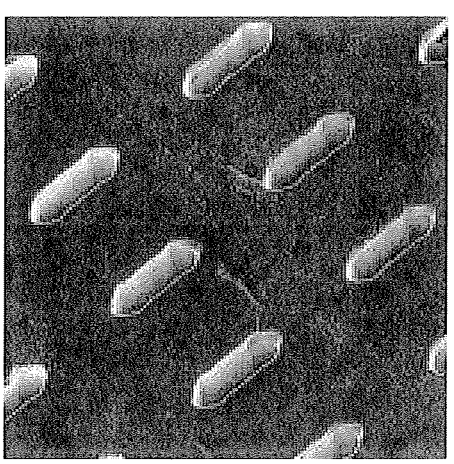


Fig. 4

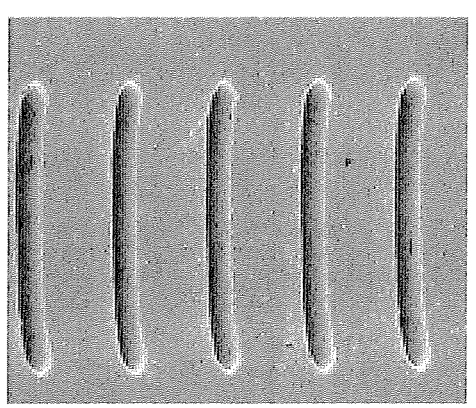


Fig. 5

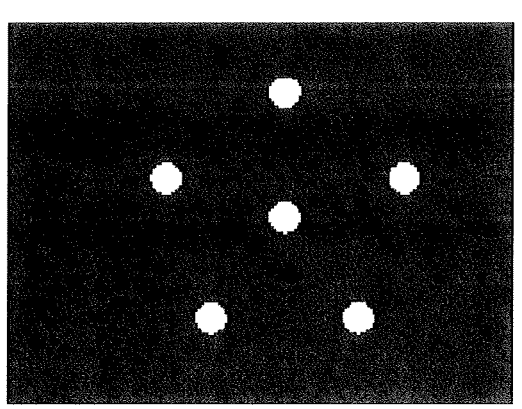


Fig. 6

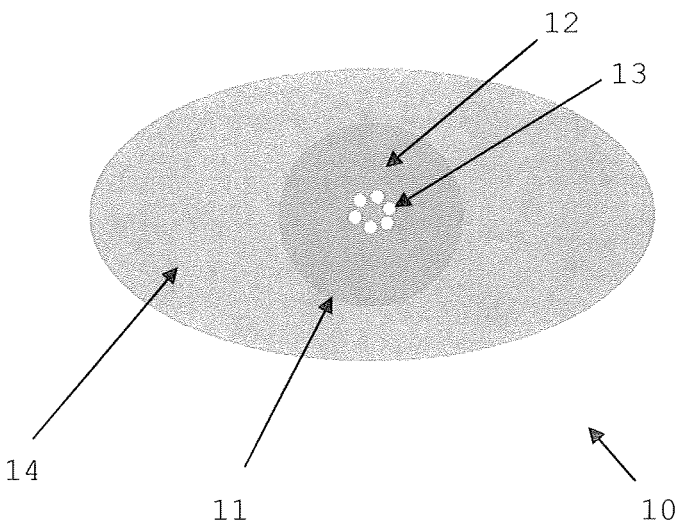


Fig. 7

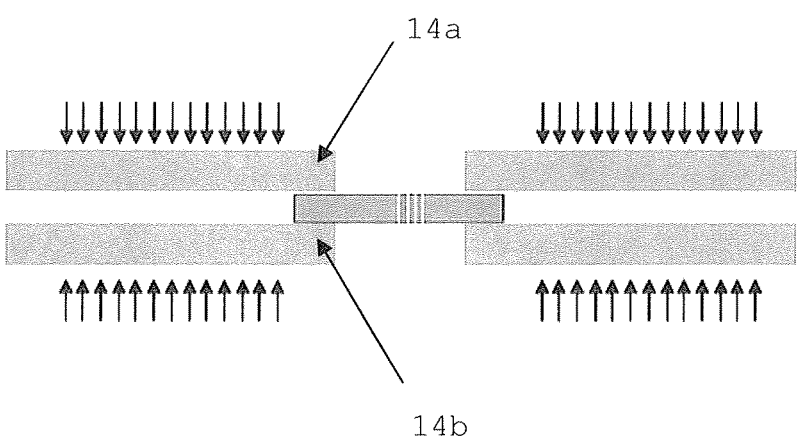


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/068786

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M12/06 H01M12/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/072383 A2 (INSOUND MEDICAL INC [US]; GABLE RICHARD [US]; BAKER ROSS [US]; O'HARA) 11 August 2005 (2005-08-11) cited in the application paragraph [0037] - paragraph [0044]; claims 1-32; figures 6-9 paragraph [0013] - paragraph [0017]	1,3-9, 14-16, 18-20
X	CN 2 859 832 Y (BEIJING CHANGLI UNION ENERGY S [CN]) 17 January 2007 (2007-01-17) the whole document	1,18-20
A	WO 94/01898 A1 (AER ENERGY RESOURCES INC [US]) 20 January 1994 (1994-01-20) the whole document	1-20

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 August 2012	24/08/2012

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/068786

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006/292427 A1 (BARTLING BRANDON A [US] ET AL) 28 December 2006 (2006-12-28) the whole document	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/068786

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