

Method for Testing a Hemispherical Shell for the Production of a Piezoceramic Hydrophone

The invention relates to a method for testing a hemispherical shell for the production of a piezoceramic hydrophone, a method for batch testing of piezoceramic hydrophones, a method for combined testing and production of a piezoceramic hydrophone and a piezoceramic hydrophone obtainable according to the method according to the invention.

Underwater locating systems such as SONAR (sound navigation and ranging) systems have been used mainly in military applications for over a hundred years. A distinction must be made essentially between active and passive (sonar) locating systems. While active systems, such as the ASDIC system (Anti Submarine Detection Investigation Committee) developed during World War II, emit and receive sound waves, in passive systems only the signals emitted by the environment are received and then evaluated. The advantage of passive systems is that they do not emit self-localizable signals. However, the precise spatial location of underwater objects is more difficult by means of passive systems alone. For many surface and underwater vehicles, both passive and active sonar systems are usually used and depending on the task profile.

In known hydrophones, two hollow hemispheres are connected to form a hollow sphere. DE 102 12 291 C1 and US 6,029,113 A disclose hollow hemispheres consisting of a piezoceramic material. The hollow hemispheres are polarized in opposite directions and an inner and an outer electrode of each hollow sphere are connected to an inverted voltage amplifier by a resistor. An exemplary structure of a hydrophone can also be found in DE 10 2008 029 269 A1, [0002], [0007]-[0008] and [0018]-[0024].

The actual hollow sphere is still often shielded against external influences such as moisture and dirt with a polymer sheath. This polymer sheath must be adapted for use in connection with a hydrophone in terms of the speed of sound and the long-term stability of the material.

The quality of the outer layer, which usually includes silver and optionally (glass-like) silicon compounds, is crucial for the functioning and quality of the hydrophone. However, an incomplete or defective surface of the outer layer significantly limits the function and effectiveness of the hydrophone. At the same time, defects on the silvery/grey surface are difficult or even impossible to detect.

US 6,029,113 A discloses the structure of a differential hydrophone comprising a ceramic sphere of two piezoelectric hemispheres. The arrangement allows the registration of acoustic signals caused by changes in the water pressure and their conversion into electrical signals.

- 5 DE 102 12 291 C1 discloses an underwater antenna with at least one hydrophone and a symmetrical electrical amplification circuit associated with the hydrophone.

DE 10 2008 029 269 A1 discloses a hydrophone for an underwater antenna, which has two hemispherical shells combined into a hollow sphere of radially polarized, piezoelectric material and electrodes covering the inner and outer shell surfaces. The hemispherical shells are fixed
10 with their shell edges mirror-symmetrically to the bottom and top of a carrier beam.

The present invention has the object to provide a method for testing a hemispherical shell for the production of a piezoceramic hydrophone, which allows the assessment of the quality and
15 completeness of the outer layer on the hemispherical shell.

The object of the invention is unexpectedly achieved by a method for testing a spherical half shell for the production of a piezoceramic hydrophone as claimed in claim 1. Further advantageous embodiments can be found in the dependent claims.

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Furthermore, the invention includes a method for batch testing of piezoceramic hydrophones. Further advantageous embodiments can be found in the dependent claims.

The invention further includes a method for the combined testing and production of a piezoceramic hydrophone. Further advantageous embodiments can be found in the dependent
25 claims.

Furthermore, the invention includes a piezoceramic hydrophone obtainable by the method according to the invention.

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The method according to the invention for testing a hollow sphere for the production of a piezoceramic hydrophone includes at least the following steps. In a base step, the determination is carried out of a threshold value sw.1 from a predetermined maximum number of non-black-colored defects and/or a threshold value sw.2 of a size of non-black-colored defects and/or a threshold value sw.3 of the position of non-black-colored defects. For the
35 purposes of the invention, both one, two or three of the threshold values sw.1, sw.2 and/or sw.3 can be determined. The expression "size of non-black-colored defects" preferably

includes in the sense of the invention an average size, expressed as an area or a maximum diameter. Alternatively, multiple threshold values sw.2 may be included for all of the non-black-colored defects counted in the sw.1 threshold value. In the plasma treatment used in the further method, a silver-containing outer layer turns black. In places where the outer layer does not contain enough silver or does not contain any silver, there is no or only minor black coloration. The same applies to soiled or damaged areas of the outer layer. The black coloration caused by the plasma treatment indicates black oxidized silver and thus a homogeneous surface. Defects preferably remain in the original silver-grey color and are referred to by the inventors as non-black-colored defects.

The selection of the threshold values sw.1 and/or sw.2 and/or sw.3 is based on pre-defined numerical values or ranges on the outer layer of the hollow sphere. For example, a threshold value sw.1 equal to zero is conceivable, i.e. no visible defects may be detectable. Preferably, in the sense of the invention, non-black-colored defects are included which are visible with the average human eye. In the context of the invention, however, optical measurement methods, for example with cameras and sensors in the field of visible, UV and infrared light as well as laser are included. Alternatively, the number, size and/or position (sw.1, sw.2, sw.3) can also be determined by electromagnetic methods, for example by surface conductivity. The threshold values for determining the number of defects, i.e. from when a position on the plasma-treated outer layer is counted as a defect, can be determined individually depending on the requirements on the hydrophone and on the basis of the measurement accuracy.

In a first step of the method, an outer layer comprising silver and optionally silicon compounds is applied on a first hemispherical shell and is applied on a second hemispherical shell. The term "outer layer" preferably includes in the sense of the invention an at least partial coating of the hemispherical shell surfaces. The expression "partial" includes in the sense of the invention a coating preferably of at least 30 %, particularly preferably at least 75 % of the hemispherical shell surfaces. In order to avoid a short circuit, individual sections of the hemispherical shell surfaces of the first hemispherical shell and the second hemispherical shell may be implemented without an outer layer (coating) or with an insulating layer or an insulating element arranged in between. This includes, for example, the surfaces of the two hemispherical shells connecting them to each other. The expression "outer layer" preferably includes a coating on the surface of the hemispherical shell, particularly preferably the inner and outer shell surfaces of the respective hemispherical shell. The outer layer comprises silver and/or silicon compounds, or equivalent thereto "contains" silver and/or silicon compounds. The application can be carried out, for example, by means of a brush, a spraying method, an

immersion method or also by means of PVD (physical vapor deposition) or CVD (chemical vapor deposition).

5 In a subsequent step, the outer layer is sintered and/or calcined and a first coated hemispherical shell and a second coated hemispherical shell are obtained.

The first coated hemispherical shell is then joined together with the second coated hemispherical shell to form a hollow sphere.

10 In a next step, the plasma treatment of the outer layer and obtaining a plasma-treated hollow sphere with a black-colored outer layer are carried out. The plasma treatment can be carried out in the manner known to the person skilled in the art, for example in a plasma containing oxygen. The parameters must be chosen in the known way so that oxidation and black coloration of the silver-containing outer layer take place.

15 In a further step, the testing is carried out of the black-colored outer layer for a number of non-black-colored defects and obtains a first value w.1; and/or for a size of non-black-colored defects and obtains a second value w.2; and/or for a position of non-black-colored defects and obtains a third value w.3. Subsequently, the values are compared w.1 with sw.1 and/or w.2 with sw.2 and/or w.3 with sw.3. Then the plasma-treated hollow sphere is removed or sorted out if w.1 is greater than sw.1 and/or w.2 is greater than sw.2 and/or w.3 is greater than sw.3. If none of the above conditions is met, the outer layer has sufficient homogeneity, and can be reinstalled in a hydrophone, for example, after a subsequent reduction. Alternatively, the method according to the invention can be used for batch testing of hemispherical shells.

25 In a preferred embodiment, the plasma treatment is carried out at an oxygen content of 80 vol. % up to 100 vol. %. The oxygen content mentioned allows sufficient oxidation and black coloration of the surface of the silver-containing outer layer.

30 Preferably, the plasma treatment is carried out at an inert gas content of 1 to 20 vol. %. Particularly preferably, the inert gas portion contains the elements or compounds N₂, Xe, He, Ar, CO₂ and/or mixtures thereof.

35 In a further preferred embodiment, the testing of the black-colored outer layer for a number of non-black-colored defects is carried out using a boundary pattern catalog. In this, the values sw.1, sw.2 and/or sw.3 and/or other threshold values are preferably listed.

Preferably, the hollow sphere is cleaned mechanically and/or wet chemically before the plasma treatment of the outer layer. Mechanical cleaning methods include sand/particle blasting methods and brushes. In the context of wet-chemical cleaning, for example, commercially available cleaning mixtures based on hydrocarbons can be used. Particularly preferably, mechanical cleaning is carried out with corundum blasting.

The invention further includes a method for batch testing of piezoceramic hydrophones at least including the following steps. The previous explanations of the threshold values and defects apply. In a base step, a threshold value sw.1 is determined from a predetermined maximum number of non-black-colored defects and/or a threshold value sw.2 of a size of non-black-colored defects is determined and/or a threshold value sw.3 of the position of non-black-colored defects is determined. For the purposes of the invention, one, two or three of the threshold values sw.1, sw.2 and/or sw.3 can be determined. The expression "size of non-black-colored defects" preferably includes in the sense of the invention an average size, expressed as an area or a maximum diameter. Alternatively, multiple threshold values sw.2 may be included for all of the non-black-colored defects counted in the sw.1 threshold value. In the plasma treatment used in the further method, an outer layer containing silver turns black. In places where the outer layer does not contain enough silver or does not contain any silver, there is no or only minor black coloration. The same applies to soiled or damaged areas of the outer layer. The black coloration caused by the plasma treatment shows black oxidized silver and thus a homogeneous surface. Defects preferably remain in the original silver-grey color and are referred to by the inventors as non-black-colored defects.

The selection of the threshold values sw.1 and/or sw.2 and/or sw.3 is based on pre-defined numerical values or ranges on the outer layer of the hollow sphere. For example, a threshold value sw.1 equal to zero is conceivable, i.e. no visible defects may be detectable. Preferably, in the sense of the invention, non-black-colored defects are included, which are visible with the average human eye. In the context of the invention, however, optical measurement methods, for example by means of cameras and sensors in the field of visible, UV and infrared light as well as laser are included. Alternatively, the number, size and position (sw.1, sw.2, sw.3) can also be determined by electromagnetic methods, for example by surface conductivity. The threshold values for determining the number of defects, i.e. from when a position on the plasma-treated outer layer is counted as a defect, can be determined individually depending on the requirements on the hydrophone and on the basis of the measurement accuracy.

In a first step of the method, an outer layer including silver and optionally silicon compounds is applied on a first hemispherical shell and is applied on a second hemispherical shell. The

term "outer layer" preferably includes in the sense of the invention an at least partial coating of the hemispherical shell surfaces. The expression "partial" includes in the sense of the invention a coating preferably of at least 30 %, particularly preferably at least 75 % of the hemispherical shell surfaces. In order to avoid a short circuit, individual sections of the hemispherical shell surfaces of the first hemispherical shell and the second hemispherical shell may be implemented without an outer layer (coating) or with an insulating layer or an insulating element arranged in between. This includes, for example, the surface connecting the two hemispherical shells to each other. The expression "outer layer" preferably includes a coating on the surface of the hemispherical shell, particularly preferably the inner and outer shell surfaces of the respective hemispherical shell. The outer layer has silver and/or silicon compounds, or equivalent thereto "contains" silver and/or silicon compounds. The application can be carried out, for example, by means of a brush, a spraying process, an immersion method or also by means of PVD (physical vapor deposition) or CVD (chemical vapor-deposition).

In a subsequent step, the outer layer is sintered and/or calcined and a first coated hemispherical shell and a second coated hemispherical shell are obtained.

The first coated hemispherical shell is then joined together with the second coated hemispherical shell to form a first hollow sphere.

The steps described above are repeated and a second or preferably multiple further hollow spheres are obtained.

In a next step the plasma treatment of the outer layer of the first hollow sphere is carried out and a plasma-treated first hollow sphere with a black-colored outer layer is obtained. The plasma treatment can be carried out in the manner known to the person skilled in the art, for example in a plasma containing oxygen. The parameters must be chosen in the known way so that oxidation and black coloration of the silver-containing outer layer take place.

In a further step, the testing is carried out of the black-colored outer layer for a number of non-black-colored defects and obtains a first value $w.1$; and/or for a size of non-black-colored defects and obtains a second value $w.2$; and/or for a position of non-black-colored defects and obtains a third value $w.3$. Subsequently, the values are compared $w.1$ with $sw.1$ and/or $w.2$ with $sw.2$ and/or $w.3$ with $sw.3$. Then the plasma-treated first hollow sphere and the second hollow sphere are removed or sorted out if $w.1$ is greater than $sw.1$ and/or $w.2$ is greater than

sw.2 and/or w.3 is greater than sw.3. If none of the above conditions is met, the outer layer has sufficient homogeneity, and the method will continue as described below.

The second hollow sphere is provided with a polymer sheath after electrical contacting. The electrical contacting of the second hollow sphere can also be carried out in the sense of the invention before assembling the second hollow sphere from the individual hemispheres. After the previous steps and any further optional steps, a piezoceramics hydrophone will be obtained.

We prefer an adhesion promoter to be applied to the second hollow sphere before applying the polymer sheath.

The invention further includes a method for combining testing and production of a piezoceramic hydrophone at least including the following steps. In a base step, a threshold value sw.1 is determined from a predetermined maximum number of non-black-colored defects and/or a threshold value sw.2 is determined of a size of non-black-colored defects and/or a threshold value sw.3 is determined of the position of non-black-colored defects. For the purposes of the invention, both one, two or three of the threshold values sw.1, sw.2 and/or sw.3 can be determined. The expression "size of non-black-colored defects" preferably includes in the sense of the invention an average size, expressed as an area or a maximum diameter. Alternatively, multiple threshold values sw.2 may be included for all of the non-black-colored defects counted in the sw.1 threshold value. During the plasma treatment used in the further method, an outer layer containing silver turns black. In places where the outer layer does not contain enough silver or does not contain any silver, there is no or only minor black coloration. The same applies to soiled or damaged areas of the outer layer. The black coloration caused by the plasma treatment shows black oxidized silver and thus a homogeneous surface. Defects preferably remain in the original silver-grey color and are referred to by the inventors as non-black-colored defects.

The selection of the threshold values sw.1 and/or sw.2 and/or sw.3 is based on pre-defined numerical values or ranges on the outer layer of the hollow sphere. For example, a threshold value sw.1 equal to zero is conceivable, i.e. no visible defects may be detectable. Preferably, in the sense of the invention, non-black-colored defects are included which are visible with the average human eye. In the context of the invention, however, optical measurement methods, for example by means of cameras and sensors in the field of visible, UV and infrared light as well as laser are included. Alternatively, the number, size and position (sw.1, sw.2, sw.3) can also be determined by electromagnetic methods, for example by surface conductivity. The

threshold values for determining the number of defects, i.e. from when a position on the plasma-treated outer layer is counted as a defect, can be determined individually depending on the requirements on the hydrophone and on the basis of the measurement accuracy.

5 In a first step of the method, an outer layer comprising silver and optionally silicon compounds is applied on a first hemispherical shell and is applied on a second hemispherical shell. The term "outer layer" preferably includes in the sense of the invention an at least partial coating of the hemispherical shell surfaces. The expression "partial" includes in the sense of the invention a coating preferably of at least 30 %, particularly preferably at least 75 % of the
10 hemispherical shell surfaces. In order to avoid a short circuit, individual sections of the hemispherical shell surfaces of the first hemispherical shell and the second hemispherical shell without an outer layer (coating) may be implemented with an insulating layer or an insulating element arranged in between. This includes, for example, the surfaces connecting the two hemispherical shells to each other. The expression "outer layer" preferably includes a coating
15 on the surface of the hemispherical shell, particularly preferably the inner and outer shell surfaces of the respective hemispherical shell. The outer layer has silver and/or silicon compounds, or equivalent thereto "contains" silver and/or silicon compounds. The application can be carried out, for example, by means of a brush, a spraying process, an immersion method or also by PVD (physical vapor deposition) or CVD (chemical vapor deposition).

20 In a subsequent step, the outer layer is sintered and/or calcined and a first coated hemispherical shell and a second coated hemispherical shell are obtained.

The first coated hemispherical shell is then joined together with the second coated
25 hemispherical shell to form a hollow sphere.

In a next step the plasma treatment of the outer layer and obtaining a plasma-treated hollow sphere with a black-colored outer layer are carried out. The plasma treatment can be carried out in the manner known to the person skilled in the art, for example in a plasma containing
30 oxygen. The parameters must be chosen in a known way such that oxidation and black coloration of the silver-containing outer layer take place.

In a further step, testing is carried out of the black-colored outer layer for a number of non-black-colored defects and obtains a first value w.1; and/or for a size of non-black-colored defects and obtains a second value w.2; and/or for a position of non-black-colored defects and obtains a third value w.3. In the following, the values w.1 are compared with sw.1 and/or w.2 with sw.2 and/or w.3 with sw.3. Then the plasma-treated hollow sphere is removed or sorted

out if w.1 is greater than sw.1 and/or w.2 is greater than sw.2 and/or w.3 is greater than sw.3. If none of the conditions mentioned is met, the outer layer has sufficient homogeneity, and the plasma-treated hollow sphere can be reinstalled in a hydrophone, for example after a subsequent reductive cleaning treatment as described below. The expression "reductive cleaning treatment" includes in the sense of the invention a treatment with a chemically reducing agent, for example a solution/suspension or reducing plasma.

Subsequently, following electrical contacting, a polymer sheathing of the hollow sphere is carried out.

Preferably, the cleaning treatment of the black-colored outer layer takes the form of a plasma treatment with 90 vol. % to 98 vol. % Ar/H₂ and 10 vol. % to 2 vol. % O₂, preferably 95 vol. % to 97 vol. % Ar/H₂ with 3 vol. % to 5 vol. % O₂.

In a further embodiment, the cleaning treatment of the black-colored outer layer in step g.) is carried out in the form of a mechanical cleaning method with, for example, blasting with corundum or scraping with a glass brush.

Preferably, before the polymer sheathing, an adhesion promoter is applied on the first cleaned coated hollow sphere.

The invention further includes a piezoceramic hydrophone obtainable by the method according to the invention.

Furthermore, the invention is explained in more detail on the basis of the following figure. The figure does not limit the scope of protection of the invention but serves only as an exemplary explanation. The figure is not true to scale.

In the figures:

Figure 1 shows a schematic cross-section of a piezoceramic hydrophone obtainable by the method according to the invention,

Figure 2 shows a schematic planar plan view of the outer layer and

Figure 3 shows a schematic planar plan view of the black-colored outer layer.

Figure 1 shows a schematic cross-section of a piezoceramic hydrophone obtainable by the method according to the invention. A first hemispherical shell (1a) and a second hemispherical shell (1b) comprising a radially polarized, piezoelectric material (for example lead zirconate titanate (PZT)) are combined to form a hollow sphere (3) with a hollow sphere volume (2). The first hemispherical shell (1a) and the second hemispherical shell (1b) have an outer layer (4). The outer layer (4) has (contains) silver and/or silicon compounds. In order to avoid a short circuit, individual sections of the hemispherical shell surfaces of the first hemispherical shell (1) and the second hemispherical shell (2) may be implemented without an outer layer (4). A polymer sheath (5) encloses the hollow sphere (3) and prevents or slows down the penetration of moisture or dirt.

Figure 2 shows a schematic planar top view on the outer layer (4). The outer layer (4) is silvery-grey. Any defects or impurities are usually not visible to the naked eye.

Figure 3 shows a schematic planar plan view on the black-colored outer layer (4a) after the plasma treatment in step c) of the method according to the invention. Defects and impurities are clearly recognizable as grey areas, as non-black-colored defects (4b). At these non-black-colored defects (4b) there is no silver layer, which would turn black in the plasma treatment and form a silver oxide layer.

Reference character list:

	(1a)	first hemispherical shell
5	(1a')	first coated hemispherical shell
	(1b)	second hemispherical shell
	(1b')	second coated hemispherical shell
	(2)	hollow sphere volume
	(3)	hollow sphere
10	(3')	plasma-treated hollow sphere
	(3.1)	first hollow sphere
	(3.1')	plasma-treated first hollow sphere
	(3.2)	second hollow sphere
	(4)	outer layer
15	(4a)	black-colored outer layer
	(4b)	non-black-colored defects
	(5)	polymer sheath

Claims

1. A method for testing a hollow sphere for the production of a piezoceramic hydrophone at least including:
 - the determination of a threshold value sw.1 from a predetermined maximum number of non-black-colored defects (4b) and/or a threshold value sw.2 of a size of non-black-colored defects (4b) and/or a threshold value sw.3 of the position of non-black-colored defects (4b);
 - a.) applying an outer layer (4) comprising silver and optionally silicon compounds on a first hemispherical shell (1a) and a second hemispherical shell (1b);
 - b.) sintering and/or calcining the outer layer (4) and obtaining a first coated hemispherical shell (1a') and a second coated hemispherical shell (1b');
 - c.) combining the first coated hemispherical shell (1a') with the second coated hemispherical shell (1b') to form a hollow sphere (3);
 - d.) plasma treatment of the outer layer (4) and obtaining a plasma-treated hollow sphere (3') with a black-colored outer layer (4a);
 - e.) testing the black-colored outer layer (4a) for:
 - a number of non-black-colored defects (4b) and obtaining a first value w.1; and/or
 - a size of non-black-colored defects (4b) and obtaining a second value w.2; and/or
 - a position of non-black defects (4b) and obtaining a third value w.3
 - f.) comparing values w.1 with sw.1 and/or w.2 with sw.2 and/or w.3 with sw.3;
 - g.) removing the plasma-treated hollow sphere (3') if w.1 is greater than sw.1 and/or w.2 is greater than sw.2 and/or w.3 is greater than sw.3.
2. The method as claimed in claim 1, **characterized in that** the plasma treatment takes place with an oxygen content of 80 vol. % to 100 vol. %.
3. The method as claimed in claim 1 or 2, **characterized in that** the plasma treatment takes place with an inert gas proportion of 1 to 20 vol. %.
4. The method as claimed in claim 3, **characterized in that** the inert gas portion contains the elements or compounds N₂, Xe, He, Ar, CO₂ and/or mixtures thereof.
5. The method as claimed in any one of claims 1 to 4, **characterized in that** the testing in step d.) is carried out by means of a boundary sample catalogue.

6. The method as claimed in any one of claims 1 to 5, **characterized in that** before the plasma treatment of the outer layer (4) the hollow sphere (3) is mechanically and/or wet chemically cleaned.
- 5 7. The method as claimed in claim 6, **characterized in that** the mechanical cleaning is carried out with corundum blasting.
8. A method for batch testing of piezoceramic hydrophones at least including the following steps:
- 10 - the determination of a threshold value sw.1 from a predetermined maximum number of non-black-colored defects (4b) and/or a threshold value sw.2 of a size of non-black-colored defects (4b) and/or a threshold value sw.3 of the position of non-black-colored defects (4b);
- a.) applying an outer layer (4) comprising silver and optionally silicon compounds on a
- 15 first hemispherical shell (1a) and second hemispherical shell (1b);
- b.) sintering and/or calcining the outer layer (4) and obtaining a first coated hemispherical shell (1a') and second coated hemispherical shell (1b');
- c.) joining the first coated hemispherical shell (1a) with the second coated hemispherical shell (1b') to form a first hollow sphere (3.1);
- 20 d.) repeating steps a.) to c.) at least once and obtaining at least one second hollow sphere (3.2)
- e.) plasma treatment of the outer layer (4) of the first hollow sphere (3.1) and obtaining a plasma-treated first hollow sphere (3.1') with a black-colored outer layer (4a);
- f.) testing of the black-colored outer layer (4a) for:
- 25 - a number of non-black defects (4b) and obtaining a first value w.1; and/or
- a size of non-black-colored defects (4b) and obtaining a second value w.2; and/or
- a position of non-black defects (4b) and obtaining a third value w.3
- g.) comparing values w.1 with sw.1 and/or w.2 with sw.2 and/or w.3 with sw.3;
- h.) removing the plasma-treated first hollow sphere (3.1') and the second hollow
- 30 sphere (3.2) if w.1 is greater than sw.1 and/or w.2 is greater than sw.2 and/or w.3 is greater than sw.3;
- i.) applying a polymer sheath (5) and preceding electrical contacting to the second hollow sphere (3.2) if the first hollow sphere (3.1') has not been removed in step h.
- 35 9. The method as claimed in claim 8, **characterized in that** before application of the polymer sheath (5) in step i.) an adhesion promoter is applied to the second hollow sphere (3.2).

10. A method for the combined testing and manufacture of a piezoceramic hydrophone at least including the following steps:

- the determination of a threshold value sw.1 from a predetermined maximum number of non-black-colored defects (4b) and/or a threshold value sw.2 of a size of non-black-colored defects (4b) and/or a threshold value sw.3 of the position of non-black-colored defects (4b);

a.) applying an outer layer (4) comprising silver and optionally silicon compounds on a first hemispherical shell (1a) and second hemispherical shell (1b);

b.) sintering and/or calcining the outer layer (4) and obtaining a first coated hemispherical shell (1a') and second coated hemispherical shell (1b');

c.) combining the first coated hemispherical shell (1a) with the second cleaned coated hemispherical shell (1b'') to form a hollow sphere (3);

d.) plasma treatment of the outer layer (4) and obtaining a plasma-treated hollow sphere (3') with a black-colored outer layer (4a);

e.) testing of the black-colored outer layer (4a) for:

- a number of non-black defects (4b) and obtaining a first value w.1; and/or
- a size of non-black-colored defects (4b) and obtaining a second value w.2; and/or
- a position of non-black defects (4b) and obtaining a third value w.3

f.) comparing the values w.1 with sw.1 and/or w.2 with sw.2 and/or w.3 with sw.3;

g.) removing the plasma-treated hollow sphere (3') if w.1 is greater than sw.1 and/or w.2 is greater than sw.2 and/or w.3 is greater than sw.3.

h.) if the plasma-treated hollow sphere (3') is not removed in step g.) a cleaning treatment of the black-colored outer layer (4a) on the plasma-treated hollow sphere (3') and obtaining a first cleaned coated hollow sphere (3'') are carried out, otherwise the method will be terminated;

i.) polymer sheathing (5) and preceding electrical contacting of the hollow sphere (3) are carried out.

11. The method as claimed in claim 10, **characterized in that** the cleaning treatment of the black-colored outer layer (4a) in step h.) is carried out in the form of a plasma treatment with 90 vol. % to 98 vol. % Ar/H₂ and 10 vol. % to 2 vol. % O₂, preferably 95 vol. % to 97 vol. % Ar/H₂ with 3 vol. % to 5 vol. % O₂.

12. The method as claimed in claim 10 or 11, **characterized in that** the cleaning treatment of the black-colored outer layer (4a) in step h.) in the form of a mechanical cleaning method with for example blasting with corundum or scraping with a glass brush.

13. The method as claimed in any one of claims 10 to 12, **characterized in that** before the polymer sheath an adhesion promoter is applied on the first cleaned coated hollow sphere (3").

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14. A piezoceramic hydrophone obtainable by a method as claimed in any one of claims 10 to 13.