

ELECTRON BEAM GENERATING DEVICE AND ELECTRON MICROSCOPE

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application is based on and claims priority to the Chinese Patent Application No. 202111030691.6 filed on September 03, 2021, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention belongs to the technical field of microscopes, and in particular relates to an electron beam generating device and an electron microscope.

BACKGROUND

[0003] In related art, an electron microscope is a commonly used microscopic analysis instrument. Usually, an electron beam is converged onto the sample to be detected through an objective lens of the electron microscope to generate a micro beam spot. In this micro area, the electron beam acts on the sample to be detected to generate signal electrons, such as secondary electrons and backscattered electrons, so that the signal electrons can be detected by the detector, so as to observe the morphology of the surface of the sample to be detected and to analyze the material composition of the sample to be detected.

[0004] As a novel electron source, the field emission electron source has the characteristics of high current density, high energy and good stability of electron beam. However, the field emission electron source has strict requirements on the vacuum degree, and thus requires the ultra-high vacuum degree. Thus, poor vacuum degree may lead to a significant reduction in the lifetime and the performance of the electron source. Therefore, an urgent technical problem to be solved is how to improve the vacuum

degree of the vacuum chamber in which the field emission electron source operates.

[0005] In view of this, the present invention is particularly proposed.

SUMMARY

[0006] The technical problem to be solved by the embodiments of the present invention is to provide an electron beam generating device and an electron microscope to overcome the deficiencies in the related art, so that the gas generated by the impact of the electrons on the inner wall of the vacuum chamber is reduced, and the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Moreover, the lifetime and the performance of the electron beam generating device are guaranteed.

[0007] In order to solve the abovementioned technical problems, the basic concept of the technical solution adopted by the embodiments of the present invention is as follows.

[0008] An electron beam generating device, including:

[0009] a cathode configured to emit a plurality of electrons;

[0010] an extraction electrode provided with an extraction hole through which the plurality of the electrons pass to form an electron beam;

[0011] a first diaphragm cylinder, in which an upper end surface of the first diaphragm cylinder is connected to a lower surface of the extraction electrode, and a bottom portion of the first diaphragm cylinder is provided with a first diaphragm hole corresponding to the extraction hole.

[0012] In some alternative implementations, an aperture of the first diaphragm hole is less than or equal to an aperture of the extraction hole.

[0013] In some alternative implementations, the electron beam generating device further includes:

[0014] a shielding tube arranged on an upper surface of the extraction electrode, in which a center of the extraction hole is located on an axis of the shielding tube.

[0015] In some alternative implementations, the electron beam generating device further includes:

[0016] an acceleration electrode arranged below the first diaphragm cylinder and provided with an acceleration hole corresponding to the first diaphragm hole.

- [0017] An aperture of the acceleration hole is greater than or equal to an aperture of the first diaphragm hole.
- [0018] In some alternative implementations, the electron beam generating device further includes:
- [0019] a second diaphragm cylinder, in which an upper end surface of the second diaphragm cylinder is connected to a lower surface of the acceleration electrode, and a bottom portion of the second diaphragm cylinder is provided with a second diaphragm hole corresponding to the acceleration hole.
- [0020] An aperture of the second diaphragm hole is less than or equal to an aperture of the acceleration hole.
- [0021] In some alternative implementations, the electron beam generating device further includes:
- [0022] a suppression electrode arranged between the cathode and the extraction electrode and provided with a suppression hole corresponding to the extraction hole.
- [0023] A lower port of the suppression hole is arranged within the shielding tube.
- [0024] In addition to the abovementioned electron beam device, an embodiment of the present invention also provides an electron microscope, which includes any one of the abovementioned electron beam generating devices.
- [0025] By adopting the abovementioned technical solutions, the embodiments of the present invention have the following beneficial effects compared with the related art. In the electron beam generating device provided by the embodiment of the present invention, the first diaphragm cylinder is arranged on the lower surface of the extraction electrode, and the electron beam passes through the extraction hole. Part of the electrons do not continue to pass through the first diaphragm hole and impact within the first diaphragm cylinder, so that the gas generated by the impact of the electrons on the inner wall of the vacuum chamber is reduced, and the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.
- [0026] Specific implementations of the present invention will be described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The accompanying drawings, which constitute a part of the present invention, are used to provide a further understanding of the present invention. The illustrative embodiments of the present invention and the illustrations thereof, which are used for explaining the present invention, do not constitute improper definitions on the present invention. It is apparent that the accompanying drawings in the following description are only some embodiments, and persons of ordinary skill in the art may still derive other drawings from these accompanying drawings without any creative effort. In the accompanying drawings:

[0028] FIG. 1 is a schematic diagram of an implementation of an electron beam generating device according to an embodiment of the present invention;

[0029] Fig. 2 is a schematic diagram of another implementation of an electron beam generating device according to an embodiment of the present invention; and

[0030] Fig. 3 is a schematic diagram of still another implementation of an electron beam generating device according to an embodiment of the present invention.

[0031] In the accompanying drawings: 1-cathode; 2-suppression electrode; 3-shielding tube; 4-extraction electrode; 5-first diaphragm cylinder; 6-electron beam; 7-acceleration electrode; 8-second diaphragm cylinder; 9-suppression hole; 10-extraction hole; 11-first diaphragm hole; 12-acceleration hole; 13-second diaphragm hole; 14-second chamber; 15-first chamber.

[0032] It should be noted that these accompanying drawings and textual descriptions are not intended to limit the scope of the concept of the present invention in any manner, but to explain the concept of the present invention to those skilled in the art with reference to specific embodiments.

DETAILED DESCRIPTION

[0033] In order to make the purpose, technical solutions and advantages of the embodiments of the present invention clearer, the technical solutions in the embodiments of the present invention will be described clearly and completely below with reference to the accompanying drawings in the embodiments of the present invention. The following

embodiments are used to illustrate the present invention, but are not used to limit the scope of the present invention.

[0034] In the description of the present invention, it should be noted that the terminologies “upper”, “lower”, “front”, “rear”, “left”, “right”, “vertical”, “inner”, “outer” and the like that indicate relations of directions or positions are based on the relations of directions or positions shown in the accompanying drawings, which are only to facilitate description of the present invention and to simplify the description of the present invention, rather than to indicate or imply that the referred device or element is limited to the specific direction or to be operated or configured in the specific direction. Therefore, the abovementioned terminologies shall not be interpreted as confine to the present invention.

[0035] In the description of the present invention, it should be noted that, unless otherwise definitely specified and limited, terms “install”, “mutually connect”, and “connect” should be broadly understood. For example, the terms may refer to fixed connection and may also refer to detachable connection or integrally connected. The terms may refer to mechanical connection and may also refer to electrical connection. The terms may refer to direct mutual connection, may also refer to indirect connection through an intermediate medium. For those of ordinary skill in the art, specific meanings of the abovementioned terms in the present invention can be understood according to a specific condition.

[0036] As shown in FIG. 1 to FIG. 3, an embodiment of the present invention provides an electron beam generating device, which includes: a cathode 1, an extraction electrode 4, and a first diaphragm cylinder 5.

[0037] The cathode 1 is configured to emit a plurality of electrons. The extraction electrode 4 is provided with an extraction hole 10. The plurality of electrons pass through the extraction hole 10 to form an electron beam 6.

[0038] An upper end surface of the first diaphragm cylinder 5 is connected to a lower surface of the extraction electrode 4, and a bottom portion of the first diaphragm cylinder 5 is provided with a first diaphragm hole 11 corresponding to the extraction hole 10.

[0039] Specifically, the electron beam generating device is arranged in a vacuum chamber. The cathode 1 emits a large number of electrons after being energized and heated. The extraction electrode 4 is arranged below the cathode 1, and the extraction

electrode 4 is provided with the extraction hole 10. The plurality of electrons pass through the extraction hole 10 to form the electron beam 6. The first diaphragm cylinder 5 is cylindrical. The bottom portion of first diaphragm cylinder is provided with the first diaphragm hole 11, and the first diaphragm hole 11 corresponds to the extraction hole 10. The upper end surface of the first diaphragm cylinder 5 is connected to the lower surface of the extraction electrode 4. The first diaphragm cylinder 5 and the lower surface of the extraction electrode 4 form a first chamber 15.

[0040] A bottom surface and an inner side wall of the first diaphragm cylinder 5 as well as a portion of the lower surface of the extraction electrode 4 form an inner wall of the first chamber 15. The electron beam 6 passes through the extraction hole 10. Part of the electrons do not continue to pass through the first diaphragm hole 11, but fall on the bottom surface of the first diaphragm cylinder 5 to impact on the bottom surface of the first diaphragm cylinder 5, and then rebound to impact on the inner side wall of the first diaphragm cylinder 5. In this way, the electrons that do not continue to pass through the first diaphragm hole 11 repeatedly impact on the inner wall of the first chamber 15 in the first chamber 15, until the energy gradually decays.

[0041] When the electrons impact on metals or alloys, these electrons will induce outgassing to generate gas. That is, when the electrons impact on the inner wall of the vacuum chamber and the inner wall of the first chamber 15, the gas will be generated, and the generated gas will affect the vacuum degree of the vacuum chamber. Degassing treatment should be performed during processing and manufacturing. Since the area of the inner wall of the first chamber 15 is smaller than the area of the inner wall of the vacuum chamber, and the overall size of the first chamber is small, the process effect of the degassing treatment is better in actual processing and production.

[0042] The electrons that do not continue to pass through the first diaphragm hole 11 are blocked within the first chamber 15, which effectively prevents the electrons that do not continue to pass through the first diaphragm hole 11 from disorderly sputtering in the vacuum chamber, so that the impact of the electrons on the inner wall of the vacuum chamber is effectively reduced, thereby reducing the gas generated by the impact of electrons on the inner wall of the vacuum chamber.

[0043] Since the space of the first chamber 15 is relatively small, the area of the inner wall of the first chamber 15 on which the electrons may impact is relatively small, the

electrons impact on the inner wall of the first chamber 15 with a smaller area for a long time, so that the gas generated from the inner wall of the first chamber 15 becomes less and less. Therefore, less gas is generated by the impact of the electrons on the inner wall of the first chamber 15, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0044] As shown in FIG. 1 to FIG. 3, in some alternative implementations, an aperture of the first diaphragm hole 11 is not greater than an aperture of the extraction hole 10.

[0045] The aperture of the first diaphragm hole 11 may change the cross-sectional area of the electron beam 6. The plurality of electrons pass through the extraction hole 10 to form the electron beam 6. The cross-sectional area of the electron beam 6 is associated with the aperture of the extraction hole 10. The electron beam 6 continues to pass through the first diaphragm hole 11. During the movement of the electron beam 6 from the extraction hole 10 to the first diaphragm hole 11, the cross-sectional area of the electron beam 6 is gradually increased due to the Coulomb force between the electrons. The aperture of the first diaphragm hole 11 is set to be not greater than the aperture of the extraction hole 10. Roundness correction may be performed by the first diaphragm hole 11 on the electron beam 6, and the first diaphragm hole may further change the cross-sectional area of the electron beam 6. By setting the aperture size of the first diaphragm hole 11, the electron beam 6 with a desired cross-sectional size can be obtained.

[0046] As shown in FIG. 2 and FIG. 3, in some alternative implementations, the embodiment of the present invention provides an electron beam generating device, which further includes a shielding tube 3 arranged on the upper surface of the extraction electrode 4. The center of the extraction hole 10 is located on an axis of the shielding tube 3.

[0047] The electron beam generating device is arranged in the vacuum chamber. The cathode 1 emits a large number of electrons after being energized and heated. The extraction electrode 4 is arranged below the cathode 1, and the extraction electrode 4 is provided with an extraction hole 10. The plurality of electrons pass through the extraction hole 10 to form the electron beam 6. Part of the electrons generated by the cathode 1 do not pass through the extraction hole 10, but fall on the upper surface of the extraction electrode 4 to impact on the upper surface of the extraction electrode 4, and then rebound

to impact on the inner wall of the vacuum chamber. The electrons are disorderly sputtered in the vacuum chamber, until the energy gradually decays. Since the area of the inner wall of the vacuum chamber is relatively large, the electrons impact on the inner wall of the vacuum chamber to generate gas, which will affect the vacuum degree of the vacuum chamber.

[0048] In this implementation, the shielding tube 3 is provided on the upper surface of the extraction electrode 4, and the center of the extraction hole 10 is located on the axis of the shielding tube 3. Part of the electrons generated by the cathode 1 do not pass through the extraction hole 10, but fall on the upper surface of the extraction electrode 4 to impact on the upper surface of the extraction electrode 4, and then rebound to impact on the inner wall of the shielding tube 3. Most of the electrons are disorderly sputtered in the shielding tube 3, until the energy gradually decays. Based on the same principle as the first chamber 15, since the space within the shielding tube 3 is relatively small, and the area of the inner wall of the shielding tube 3 on which the electrons may impact is relatively small, the gas generated by the impact of the electrons on the inner wall of the shielding tube 3 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0049] As shown in FIG. 3, in some alternative implementations, the embodiment of the present invention provides an electron beam generating device, which further includes an acceleration electrode 7 arranged below the first diaphragm cylinder 5. The acceleration electrode 7 is provided with an acceleration hole 12 corresponding to the first diaphragm hole 11.

[0050] The acceleration electrode 7 forms an acceleration electric field configured to increase the moving speed of the electron beam 6. The acceleration electrode 7 is arranged below the first diaphragm hole 11, and the acceleration electrode 7 is provided with the acceleration hole 12 corresponding to the first diaphragm hole 11. The electron beam 6 passing through the first diaphragm hole 11 passes through the acceleration hole 12 after the moving speed of the electron beam 6 is increased under the action of the acceleration electric field.

[0051] In the above solution, an aperture of the acceleration hole 12 is not less than the aperture of the first diaphragm hole 11.

[0052] In order to prevent the alignment error between the acceleration hole 12 and the first diaphragm hole 11 during installation, the aperture of the acceleration hole 12 is not less than the aperture of the first diaphragm hole 11, so that the electron beam 6 may be accelerated without blocking part of the electron beam 6 by the acceleration electrode 7 due to the alignment error between the acceleration hole 12 and the first diaphragm hole 11, thereby realizing that all the electron beams 6 pass through the acceleration hole 12.

[0053] As shown in FIG. 3, in some alternative implementations, the embodiment of the present invention provides an electron beam generating device, which further includes a second diaphragm cylinder 8. An upper end surface of the second diaphragm cylinder 8 is connected to a lower surface of the acceleration electrode 7, and a bottom portion of the second diaphragm cylinder 8 is provided with a second diaphragm hole 13 corresponding to the acceleration hole 12.

[0054] The upper end surface of the second diaphragm cylinder 8 is connected to the lower surface of the acceleration electrode 7, so that the second diaphragm cylinder 8 and the lower surface of the acceleration electrode 7 form a second chamber 14. The bottom surface and the inner side wall of the second diaphragm cylinder 8 as well as a portion of the lower surface of the acceleration electrode 7 form an inner wall of the second chamber 14. The electron beam 6 passes through the acceleration hole 12, and part of the electrons do not continue to pass through the second diaphragm hole 13, but fall on the bottom surface of the second diaphragm cylinder 8 to impact on the bottom surface of the second diaphragm cylinder 8, and then rebound to impact on the inner side wall of the second diaphragm cylinder 8. In this way, the electrons that do not continue to pass through the second diaphragm hole 13 repeatedly impact on the inner wall of the second chamber 14 in the second chamber 14, until the energy gradually decays.

[0055] Based on the same principle as the first chamber 15, the electrons that do not continue to pass through the second diaphragm hole 13 are blocked within the second chamber 14, which effectively prevents the electrons that do not continue to pass through the second diaphragm hole 13 from disorderly sputtering in the vacuum chamber, so that the impact of the electrons on the inner wall of the vacuum chamber is effectively reduced, thereby reducing the gas generated by the impact of the electrons on the inner wall of the vacuum chamber.

- [0056] Since the space of the second chamber 14 is relatively small, and the area of the inner wall of the second chamber 14 on which the electrons may impact is relatively small, the gas generated by the impact of the electrons on the inner wall of the second chamber 14 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.
- [0057] As shown in FIG. 3, in some alternative implementations, an aperture of the second diaphragm hole 13 is not greater than the aperture of the acceleration hole 12.
- [0058] The aperture of the second diaphragm hole 13 may change the cross-sectional area of the electron beam 6. During the movement of the electron beam 6 from the acceleration hole 12 to the second diaphragm hole 13, the cross-sectional area of the electron beam 6 is gradually increased due to the Coulomb force between the electrons. The aperture of the second diaphragm hole 13 is set to be not greater than the aperture of the acceleration hole 12. Roundness correction may be performed by the second diaphragm hole 13 on the electron beam 6, and the second diaphragm hole may further change the cross-sectional area of the electron beam 6. By setting the aperture size of the second diaphragm hole 13, the electron beam 6 with a desired cross-sectional size can be obtained.
- [0059] As shown in FIG. 2 and FIG. 3, in some alternative implementations, the embodiment of the present invention provides an electron beam generating device, which further includes a suppression electrode 2 arranged between the cathode 1 and the extraction electrode 4. The suppression electrode 2 is provided with a suppression hole 9 corresponding to the extraction hole 10.
- [0060] The suppression electrode 2 is configured to restrict the direction in which the cathode 1 emits electrons. The suppression hole 9 corresponds to the extraction hole 10. The suppression electrode 2 may suppress the cathode 1 from emitting a large number of electrons in the direction of the suppression hole 9.
- [0061] In the above solution, a lower port of the suppression hole 9 is arranged within the shielding tube 3.
- [0062] The lower port of the suppression hole 9 is arranged within the shielding tube 3. The electrons pass through the suppression hole 9, and then pass through the extraction hole 10 to form an electron beam 6. However, most of the electrons that pass through the

suppression hole 9 but do not pass through the extraction hole 10 are remained within the shielding tube 3. The electrons are disorderly sputtered within the shielding tube 3, until the energy gradually decays. Based on the same principle as the first chamber 15, since the space within the shielding tube 3 is relatively small, and the area on the inner wall of the shielding tube 3 on which the electrons may impact is relatively small, the gas generated by the impact of the electrons on the inner wall of the shielding tube 3 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0063] In addition to the abovementioned electron beam generating device, the embodiment of the present invention also provides an electron microscope, which includes the electron beam generating device provided in any one of the above embodiments. The electron beam 6 generated by the electron beam generating device is converged onto the sample to be detected through the objective lens of the electron microscope to generate a micro beam spot. In this micro area, the electron beam 6 acts on the sample to be detected to generate signal electrons, such as secondary electrons and backscattered electrons, so that the signal electrons can be detected by the detector, so as to observe the morphology of the surface of the sample to be detected and to analyze the material composition of the sample to be detected.

[0064] As shown in FIG. 1 to FIG. 3, an explanation is given below with a specific embodiment. The electron beam generating device is arranged in the vacuum chamber. A voltage V_0 is applied to the cathode 1. In this embodiment, the voltage V_0 is illustrated by taking -30 kV as an example. The cathode 1 may emit a large number of electrons after being energized and heated. The extraction electrode 4 is arranged below the cathode 1, and a voltage V_1 is applied to the extraction electrode 4. In this embodiment, the voltage V_1 is illustrated by taking -25 kV as an example. The extraction electrode 4 is provided with an extraction hole 10. The aperture of the extraction hole 10 is illustrated by taking 0.4 mm as an example. A plurality of electrons pass through the extraction hole 10 to form the electron beam 6.

[0065] The upper end surface of the first diaphragm cylinder 5 is connected to the lower surface of the extraction electrode 4. The voltage V_2 of the first diaphragm cylinder 5 is the same as the voltage V_1 . The first diaphragm cylinder 5 is cylindrical.

The first diaphragm cylinder 5 and the lower surface of extraction electrode 4 form the first chamber 15. The bottom portion of the first diaphragm cylinder is provided with a first diaphragm hole 11, and the first diaphragm hole 11 corresponds to the extraction hole 10. The aperture of the first diaphragm hole 11 is illustrated by taking 0.12 mm as an example.

[0066] The aperture of the first diaphragm hole 11 is less than the aperture of the extraction hole 10. Roundness correction may be performed by the first diaphragm hole 11 on the electron beam 6, and the first diaphragm hole may further change the cross-sectional area of the electron beam 6. By setting the aperture size of the first diaphragm hole 11, the electron beam 6 with a desired cross-sectional size can be obtained.

[0067] During the movement of the electron beam 6 from the extraction hole 10 to the first diaphragm hole 11, the cross-sectional area of the electron beam 6 is gradually increased due to the Coulomb force between the electrons. The aperture of the first diaphragm hole 11 is less than the aperture of the extraction hole 10. The electron beam 6 passes through the extraction hole 10, and part of the electrons do not continue to pass through the first diaphragm hole 11. This part of the electrons is blocked and disorderly sputtered within the first chamber 15, until the energy gradually decays. Compared with the vacuum chamber, the space of the first chamber 15 is smaller, and the area of the inner wall of the first chamber 15 on which the electrons may impact is smaller. Thus, the gas generated by the impact of the electrons on the inner wall of the first chamber 15 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0068] Optionally, the suppression electrode 2 is provided below the cathode 1. A voltage V3 is applied to the suppression electrode 2. In this embodiment, the voltage V3 is illustrated by taking -30.5 kV as an example. The suppression electrode 2 may suppress the cathode 1 from emitting a large number of electrons in the direction of the suppression hole 9. The aperture of the suppression hole 9 is illustrated by taking 0.4 mm as an example.

[0069] Optionally, the shielding tube 3 is provided on the upper surface of the extraction electrode 4, and the center of the extraction hole 10 is located on the axis of the shielding tube 3. Part of the electrons generated by the cathode 1 do not pass through

the extraction hole 10, so that this part of the electrons are disorderly sputtered within the shielding tube 3, until the energy gradually decays. Since the space within the shielding tube 3 is relatively small, and the area of the inner wall of the shielding tube 3 on which the electrons may impact is relatively small, the gas generated by the impact of the electrons on the inner wall of the shielding tube 3 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0070] Optionally, the acceleration electrode 7 is provided below the first diaphragm cylinder 5. A voltage V4 is applied to the acceleration electrode 7. In this embodiment, the voltage V4 is illustrated by taking 0 V as an example. The acceleration electrode 7 is provided with an acceleration hole 12 corresponding to the first diaphragm hole 11. The aperture of the acceleration hole 12 is illustrated by taking 4 mm as an example. The acceleration electrode 7 forms an acceleration electric field configured to increase the moving speed of the electron beam 6. The electron beam 6 passing through the first diaphragm hole 11 passes through the acceleration hole 12 after the moving speed of the electron beam 6 is increased under the action of the acceleration electric field.

[0071] Optionally, the upper end surface of the second diaphragm cylinder 8 is connected to the lower surface of the acceleration electrode 7. The voltage V5 of the second diaphragm cylinder 8 is the same as the voltage V4. The second diaphragm cylinder 8 is cylindrical. The second diaphragm cylinder 8 and the lower surface of acceleration electrode 7 form the second chamber 14. The bottom portion of the second diaphragm cylinder is provided with a second diaphragm hole 13. The second diaphragm hole 13 corresponds to the acceleration hole 12. The aperture of the second diaphragm hole 13 is illustrated by taking 0.5 mm as an example.

[0072] The aperture of the second diaphragm hole 13 is less than the aperture of the acceleration hole 12. Roundness correction may be performed by the second diaphragm hole 13 on the electron beam 6, and the second diaphragm hole may further change the cross-sectional area of the electron beam 6. By setting the aperture size of the second diaphragm hole 13, the electron beam 6 with a desired cross-sectional size can be obtained.

[0073] During the movement of the electron beam 6 from the acceleration hole 12 to

the second diaphragm hole 13, the cross-sectional area of the electron beam 6 is gradually increased due to the Coulomb force between the electrons. The aperture of the second diaphragm hole 13 is less than the aperture of the acceleration hole 12. The electron beam 6 passes through the acceleration hole 12, and part of the electrons do not continue to pass through the second diaphragm hole 13. This part of the electrons is blocked and disorderly sputtered within the second chamber 14, until the energy gradually decays. Compared with the vacuum chamber, the space of the second chamber 14 is smaller, and the area of the inner wall of the second chamber 14 on which the electrons may impact is smaller. Thus, the gas generated by the impact of the electrons on the inner wall of the second chamber 14 is less, so that the vacuum degree of the vacuum chamber in which the electron beam generating device operates is improved. Thus, the lifetime and the performance of the electron beam generating device are guaranteed.

[0074] It should be noted that the voltages, such as the voltage V0 of the cathode 1, the voltage V1 of the extraction electrode 4, the voltage V2 of the first diaphragm cylinder 5, the voltage V3 of the suppression electrode 2, the voltage V4 of the acceleration electrode 7 and the voltage V5 of the second diaphragm cylinder 8, are not limited to the specific values in the above embodiments, and the person skilled in the art may set the specific values of voltage according to actual situations.

[0075] The aperture of the extraction hole 10, the aperture of the first diaphragm hole 11, the aperture of the suppression hole 9, the aperture of the acceleration hole 12 and the aperture of the second diaphragm hole 13 are not limited to the specific values in the above embodiments, and the person skilled in the art may set the specific values of aperture according to actual situations.

[0076] The above descriptions are only preferred embodiments of the present invention, and do not limit the present invention in any form. Although the present invention has been disclosed above with the preferred embodiments, it is not intended to limit the present invention. Any person familiar with this application may make some changes or modifications by utilizing the above-mentioned technical content without departing from the scope of the technical solution of the present invention. Any simple modifications, equivalent changes and modifications made to the above embodiments according to the technical essence of the present invention without departing from the content of the technical solution of the present invention still fall within the scope of the

solution of the present invention.

CLAIMS

1. An electron beam generating device, comprising:
 - a cathode configured to emit a plurality of electrons;
 - an extraction electrode provided with an extraction hole through which the plurality of electrons pass to form an electron beam;
 - a first diaphragm cylinder, wherein an upper end surface of the first diaphragm cylinder is connected to a lower surface of the extraction electrode, and a bottom portion of the first diaphragm cylinder is provided with a first diaphragm hole corresponding to the extraction hole.
2. The electron beam generating device according to claim 1, wherein an aperture of the first diaphragm hole is less than or equal to an aperture of the extraction hole.
3. The electron beam generating device according to claim 1, further comprising:
 - a shielding tube arranged on an upper surface of the extraction electrode, wherein a center of the extraction hole is located on an axis of the shielding tube.
4. The electron beam generating device according to claim 1, further comprising:
 - an acceleration electrode arranged below the first diaphragm cylinder and provided with an acceleration hole corresponding to the first diaphragm hole.
5. The electron beam generating device according to claim 4, wherein an aperture of the acceleration hole is greater than or equal to an aperture of the first diaphragm hole.
6. The electron beam generating device according to claim 4, further comprising:
 - a second diaphragm cylinder, wherein an upper end surface of the second diaphragm cylinder is connected to a lower surface of the acceleration electrode, and a bottom portion of the second diaphragm cylinder is provided with a second diaphragm hole corresponding to the acceleration hole.

7. The electron beam generating device according to claim 6, wherein an aperture of the second diaphragm hole is less than or equal to an aperture of the acceleration hole.
8. The electron beam generating device according to claim 3, further comprising:
a suppression electrode arranged between the cathode and the extraction electrode and provided with a suppression hole corresponding to the extraction hole.
9. The electron beam generating device according to claim 8, wherein a lower port of the suppression hole is arranged within the shielding tube.
10. An electron microscope, comprising the electron beam generating device according to any one of claims 1 to 9.