

# **TARGET ASSEMBLY AND X-RAY MICROSCOPE**

## **CROSS-REFERENCE TO RELATED APPLICATIONS**

[ 0001]       The application claims priorities to Chinese Patent Application No. 202111031885.8, filed on September 3, 2021, and Chinese Patent Application No. 202122127470.2, filed on September 3, 2021, the disclosures of which are hereby incorporated by reference in their entirety.

## **TECHNICAL FIELD**

[ 0002]       The disclosure belongs to the technical field of microscopes, in particular to a target assembly and an X-ray microscope.

## **BACKGROUND**

[ 0003]       In the related art, an X-ray microscope is used for scanning the plane of a layer located at a certain depth of a portion of a sample to be tested with a beam of an X-ray, and the X-ray passes through the layer, and is received by a detector, where it is converted into visible light, then converted into electrical signals by photoelectric conversion, and last treated by a computer to form a three-dimensional CT image. The CT image can reflect the geometric information and structural information of the sample to be tested. The former includes the size, volume and spatial coordinates of each point of the sample to be tested, and the latter includes material science information such as attenuation value, density and porosity of the sample to be tested.

[ 0004]       An electron beam acts on a target and generates the X-ray in an action area, and the X-ray is scattered towards periphery from the action area. The imaging quality of an X-ray microscope is largely related to the X-ray density in an effective irradiation area. Although an optical device is used in some X-ray generating devices to focus the produced X-ray, the space of the X-ray microscope is too limited to accommodate an optical device. How to increase the X-ray density within an effective irradiation area

without an optical device to improve the imaging quality of an X-ray microscope becomes an urgent problem for those skilled in the art.

[ 0005] In view of this, the disclosure is proposed.

## SUMMARY

[ 0006] The technical problem to be solved by the disclosure is to overcome the deficiency in the related art. Accordingly, embodiments of the disclosure provide a target assembly and an X-ray microscope, in which the target assembly increases the X-ray density in an effective irradiation area and thus improves the imaging quality of the X-ray microscope.

[ 0007] To solve the above technical problem, the basic concept of the technical solution of the disclosure is as follows. A target assembly is provided, which includes a first section including a first heat dissipating layer, in which the first heat dissipating layer is provided with a first groove, and a first target is arranged in the first groove, the first target is provided with a first action surface that is configured to be acted by an electron beam, and the first action surface is arranged to be inclined with respect to a bottom surface of the first groove.

[ 0008] Furthermore, the first heat dissipating layer is provided with at least two first grooves, each of the first grooves is provided with one first target, and inclination angles of the at least two first action surfaces are different.

[ 0009] Furthermore, the target assembly also includes a second section including a second heat dissipating layer, in which the second heat dissipating layer is provided with a second groove, and a second target is arranged in the second groove, and the second target is provided with a second action surface that is configured to be acted by the electron beam, and the second action surface is arranged in parallel with a bottom surface of the second groove.

[ 0010] Furthermore, materials of the multiple first targets are different, and the second heat dissipating layer is provided with at least two second grooves, at least two second targets are respectively arranged in the second grooves, and materials of the multiple

second targets are different.

[ 0011] According to the embodiments of the disclosure, an X-ray microscope is further provided, which includes a mounting seat provided with a clamping groove, and the target assembly is detachably installed in the clamping groove, and the mounting seat is provided with a cooling assembly for cooling the target assembly.

[ 0012] Furthermore, the mounting seat includes a first cooling side plate, a second cooling side plate, a cooling bottom plate and a cooling back plate.

[ 0013] The cooling assembly includes a first cooling coil, a second cooling coil, a third cooling coil and a fourth cooling coil.

[ 0014] An inner cavity of the first cooling side plate is provided with the first cooling coil, an inner cavity of the second cooling side plate is provided with the second cooling coil, an inner cavity of the cooling bottom plate is provided with the third cooling coil, and an inner cavity of the cooling back plate is provided with the fourth cooling coil.

[ 0015] In some embodiments, the X-ray microscope further includes: an electron optical column, a vacuum chamber and a sample stage.

[ 0016] The electron optical column is configured to emit an electron beam, and a lower end of the electron optical column is connected with a vacuum chamber provided with a vacuum window.

[ 0017] The sample stage is configured to place a sample to be tested and is arranged in the vacuum chamber.

[ 0018] The target assembly is located in the vacuum chamber, and the target assembly is acted by the electron beam to generate an X-ray, which irradiates the sample to be tested, passes through the vacuum window, and is received by an X-ray detector.

[ 0019] Furthermore, the X-ray microscope further includes a manipulator, which is configured to clamp the target assembly and move in the vacuum chamber.

[ 0020] In some embodiments, the X-ray microscope further includes a bellows, in which an end of the bellows is connected with the X-ray detector, and the other end of the bellows is connected with an outer sidewall of the vacuum chamber around the

vacuum window.

[ 0021] Furthermore, a sealed chamber is defined by the outer sidewall of the vacuum chamber, the bellows, the X-ray detector and the vacuum window, and the sealed chamber is filled with helium or nitrogen.

[ 0022] Compared with the related art, the embodiments of the disclosure adopting the above technical solutions have the following beneficial effects.

[ 0023] The target assembly and the X-ray microscope are provided by the embodiments of the disclosure. The first heat dissipating layer of the target assembly is provided with the first groove, and the first target is arranged in the first groove and has the first action surface acted by the electron beam, and the first action surface is arranged to be inclined with respect to the bottom surface of the first groove. When the electron beam acts on the first action surface, because the first action surface and the bottom surface of the first groove are obliquely arranged, the inclination angle of the first action surface can be used for controlling and adjusting the emission direction of the generated X-ray beam within the high density X-ray area. In this way, the X-ray density in an effective irradiation area is increased, and the imaging quality of an X-ray microscope is improved.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[ 0024] As a part of the disclosure, the drawings are provided for a further understanding of the disclosure. The exemplary embodiments of the disclosure and their descriptions are used to explain the disclosure, but do not constitute an improper limitation on the disclosure. Apparently, the drawings in the following description only illustrate some embodiments. For those of ordinary skill in this field, other drawings may be obtained according to these drawings without any creative effort.

[ 0025] FIG. 1 is a structural schematic diagram of a target assembly provided by an embodiment of the disclosure;

[ 0026] FIG. 2 is a structure distribution schematic diagram of an mounting seat and an cooling assembly provided by an embodiment of the disclosure;

[ 0027] FIG. 3 is a schematic diagram of the matching installation structure of an mounting seat and a target assembly provided by an embodiment of the disclosure; and

[ 0028] FIG. 4 is an overall structural schematic diagram of an X-ray microscope provided by an embodiment of the disclosure.

[ 0029] In the drawings: 1, target assembly; 101, first section; 102, second section; 2, first target; 201, first action surface; 3, first heat dissipating layer; 301, first groove; 4, second target; 401, second action surface; 5, second heat dissipating layer; 501, second groove; 6, cooling assembly; 601, first cooling coil; 602, second cooling coil; 603, third cooling coil; 604, fourth cooling coil; 7, mounting seat; 701, first cooling side plate; 702, second cooling side plate; 703, cooling bottom plate; 704, cooling back plate; 8, electron optical column; 801, electron source; 802, electron accelerating structure; 803, object lens system; 9, electron beam; 10, vacuum chamber; 11, manipulator; 12, X-ray; 13, sample to be tested; 14, sample stage; 15, vacuum window; 16, bellows; and 17, X-ray detector.

[ 0030] It should be noted that these drawings and text descriptions are not intended to limit the scope of the disclosure in any way, but to illustrate the concept of the disclosure to those skilled in the art with reference to specific embodiments.

## DETAILED DESCRIPTION

[ 0031] In order to make the purposes, technical solutions and advantages of the embodiments of the disclosure clearer, the technical solutions of the embodiments of the disclosure will be clearly and completely described below with reference to the drawings in the embodiments of the disclosure. The following embodiments are used to illustrate the disclosure, but not to limit its scope.

[ 0032] In the description of the disclosure, it should be noted that directions or positional relationships indicated by terms “upper”, “lower”, “front”, “back”, “left”, “right”, “vertical”, “inside”, “outside” or the like are based on the directions or positional relationships shown in the drawings. It is only for the convenience of describing the embodiments of the disclosure, not for indicating or implying that the indicated device or element must have a particular orientation, be constituted and be operated in a particular

orientation, and therefore should not be construed as a limitation to the disclosure.

[ 0033] In the description of the disclosure, it should be noted that unless otherwise specified and defined, the terms “installation”, “interconnection” and “connection” should be understood in a broad sense, for example, it may be a fixed connection, a detachable connection or an integral connection; it may also be a mechanical connection or an electrical connection; and it may be direct connected or indirect connection with an intermediate medium. For those of ordinary skill in the art, the specific meanings of the above terms in the disclosure may be understood according to specific situations.

[ 0034] As shown in FIG. 1, a target assembly 1 is provided by an embodiment of the disclosure. The target assembly 1 includes a first section 101 including a first heat dissipating layer 3. The first heat dissipating layer 3 is provided with a first groove 301, and a first target 2 is arranged in the first groove 301 and provided with a first action 201 that is acted by an electron beam 9, and the first action surface 201 is obliquely arranged relative to the bottom surface of the first groove 301.

[ 0035] Specifically, the first section 101 includes the first heat dissipating layer 3, which may be made of a heat-conducting metal, diamond, graphite or a modified material of graphite.

[ 0036] The first heat dissipating layer 3 is provided with the first groove 301. The first target 2 is arranged in the first groove 301, and the bottom surface and sidewalls of the first groove 301 are attached to the first target 2. Referring to FIG. 4, when the electron beam 9 acts on the first target 2, the generated heat is dissipated through the first groove 301 that is attached to the first target 2. The bottom surface and the sidewalls of the first groove 301 attached to the first target 2 can improve the heat dissipation efficiency.

[ 0037] The first target 2 is provided with the first action surface 201 that is acted by the electron beam 9, and the first action surface 201 is inclined relative to the bottom surface of the first groove 301.

[ 0038] When the electron beam 9 acts on the first action surface 201, because the first action surface 201 and the bottom surface of the first groove 301 are obliquely arranged, the inclination angle of the first action surface 201 can be used for controlling and adjusting the emission direction of the X-ray 12 beam in a high density X-ray 12 area. In

this way, the X-ray 12 density of the effective irradiation area is increased, and the imaging quality of the X-ray microscope is improved.

[ 0039] As shown in FIG. 1, in some embodiments, the first heat dissipating layer 3 is provided with at least two first grooves 301, and each first groove 301 is provided with one first target 2, and the inclination angles of at least two first action surfaces 201 are different.

[ 0040] Specifically, the first heat dissipating layer 3 is provided with at least two first grooves 301. The multiple first grooves 301 are arranged in parallel in sequence, and a distance between two adjacent first grooves 301 is preferably not less than 500 nanometers. The groove width of each first groove 301 is preferably less than or equal to 100 nanometers. The width of each first target 2 is less than or equal to the groove width of each first groove 301. Each first groove 301 is provided with one first target 2, and the inclination angles of the at least two first action surfaces 201 are different.

[ 0041] The first action surface of the first target 2 is acted by the electron beam 9 to generate an X-ray 12. However, the first action surface 201 of the first target 2 is small, and it is hard to meet the accuracy requirement by controlling rotation of the first action surface 201 with a mechanical structure to change the angle between the first action surface 201 and the electron beam 9. As such, the emission direction of the X-ray 12 beam of the high density X-ray 12 area cannot be accurately controlled.

[ 0042] The multiple first action surfaces 201 are arranged with different inclination angles in the embodiment. As the multiple first action surfaces 201 with different inclination angles are arranged on the target assembly 1, a linear movement of the target assembly 1 can be controlled with a mechanical structure, thereby driving the first action surfaces 201 with the different inclination angles to move, and as a result, the first target 2 with the first action surface 201 having a required inclination angle can be selected to move linearly to the position below the electron beam 9, thereby controlling and adjusting the emission direction of the generated X-ray 12 beam of the high density X-ray 12 area. In this way, the X-ray 12 density in the effective irradiation area is increased and the imaging quality of an X-ray microscope is improved.

[ 0043] As shown in FIG. 1, the target assembly 1 provided by an embodiment of the disclosure further includes a second section 102 including a second heat dissipating layer

5, which is provided with a second groove 501, and a second target 4 is arranged in the second groove 501 and provided with a second action surface 401 that is acted by the electron beam 9, and the second action surface 401 is arranged parallel to the bottom surface of the second groove 501.

[ 0044]        Specifically, the second section 102 includes the second heat dissipating layer 5, which may be made of a heat-conducting metal, diamond, graphite, or a modified material of graphite.

[ 0045]        The second heat dissipating layer 5 is provided with the second groove 501, and the second target 4 is arranged in the second groove 501, and the bottom surface and sidewalls of the second groove 501 are attached to the second target 4. When the electron beam 9 acts on the second target 4, the generated heat will be dissipated through the second groove 501 that is attached to the second target 4. The bottom and the sidewalls of the second groove 501 attached to the second target 4 can improve the heat dissipation efficiency.

[ 0046]        The second target 4 has the second action surface 401 that is acted by the electron beam 9, and the second action surface 401 is arranged parallel to the bottom surface of the second groove 501. The second action surface 401 is parallel to the bottom surface of the second groove 501, such that more emission directions of the high-density X-ray 12 area may be selected, since the emission direction of the X-ray 12 generated by an electron beam 9 acting on the second action surface 401 is different from the emission direction of the high-density X-ray 12 generated by an electron beam 9 acting on a inclined first action surface 201.

[ 0047]        As shown in FIG. 1, in some embodiments, the second heat dissipating layer 5 is provided with at least two second grooves 501, and the multiple second grooves 501 are arranged in parallel in sequence. A distance between two adjacent second grooves 501 is preferably more than or equal to 500 nanometers. The groove width of each second groove 501 is preferably less than or equal to 100 nanometers. The width of each second target 4 is less than or equal to the groove width of each groove 501.

[ 0048]        The linear movement of the target assembly 1 may be controlled with a mechanical structure, thereby driving different second action surfaces 401 to move, and the second target 4 with the required second action surface 401 can be selected to move

linearly to a position below the electron beam 9.

[ 0049] As shown in Figure 1, in some embodiments, the target assembly 1 is integrally formed with the first section 101 and the second section 102, and the first heat dissipating layer 3 and the second heat dissipating layer 5 are integrated, preferably with the material of diamond, by a plasma chemical vapor deposition process. The first groove(s) 301 and the second groove(s) 501 may be formed by means of shielding during the plasma chemical vapor deposition or may be formed by processing with a focused ion beam. The multiple first grooves 301 and the second groove 501 are arranged in parallel in sequence. The first targets 2 may be disposed in the first grooves 301 by a physical vapor deposition process, and the second target 4 may be disposed in the second groove 501 by a physical vapor deposition process. The inclination angles of the first action surfaces 201 of the first targets 2 may be formed by processing with a focused ion beam. In the direction from the first targets 2 to the second target 4, the inclination angles of the first action surfaces 201 of the multiple first targets 2 are configured to increase in sequence.

[ 0050] As shown in FIG.1, the target assembly 1 is provided with six first targets 2 and one second target 4. In the direction from the first targets 2 to the second target 4, the inclination angles of the first action surfaces 201 of the first one, the second one, the third one, the fourth one, the fifth one and the sixth one of the first targets 2 are 20 degrees, 25 degrees, 30 degrees, 35 degrees, 40 degrees and 45 degrees, respectively. The second action surface 401 of the second target 4 is parallel to the bottom surface of the second groove 501. The target assembly 1 may be controlled to move linearly with a mechanical structure, driving the first acted surfaces 201 with different inclination angles to move, and thus one of the first action surfaces 201 with the required inclination angle or the second action surface 401 may be selected and moved in a straight line to the position below the electron beam 9, thereby controlling and adjusting the emission direction of the generated X-ray 12 beam of the high density X-ray 12 area. In this way, the X-ray 12 density in the effective irradiation area is increased and the imaging quality of an X-ray microscope is improved.

[ 0051] It should be noted that the specific number of the first targets 2, the specific number of the second target(s) 4, the selections of the inclination angles of the first action surfaces 201 of the first targets 2, the distribution of the first targets 2 provided with the

first action surfaces 201 with different inclination angles and the distribution of the second target(s) are not limited by the above-mentioned embodiments, and those skilled in the art can choose and set them according to actual situations.

[ 0052] In some embodiments, the target assembly 1 includes multiple first targets 2 and multiple second targets 4. Specifically, the materials of the first targets 2 are different, and the materials of the second targets 4 are different.

[ 0053] The multiple first targets 2 may be made of different materials commonly used as a target material, such as manganese, chromium, copper, cobalt, nickel, tungsten, titanium or the like.

[ 0054] The second targets 4 may be made of different materials commonly used as a target material, such as manganese, chromium, copper, cobalt, nickel, tungsten, titanium or the like.

[ 0055] As shown in Figure 1, the target assembly 1 is provided with six first targets 2 and one second target 4 arranged in the direction from the first targets 2 to the second target 4.

[ 0056] Optionally, the material of the first one to the third one of the first targets 2 is manganese, and the material of the fourth one and the fifth one of the first targets 2 is chromium, and the materials of the sixth one of the first targets 2 and the second target 4 are tungsten.

[ 0057] It should be noted that a specific number of the first targets 2, a specific number of the second targets 4, selections of materials of the first targets 2, distributions of the first targets 2 with different materials, selections of materials of the second targets 4, and distributions of the second targets 4 with different materials are not limited to the above-mentioned embodiment, and those skilled in the art can choose and set them according to actual situations.

[ 0058] As shown in FIGs. 1 to 4, the embodiments of the disclosure provide an X-ray microscope, which includes a target assembly 1 in any of the above embodiments. The X-ray microscope includes a mounting seat 7, which is provided with a clamping groove, in which the target assembly 1 is detachably installed, and the mounting seat 7 is provided with a cooling assembly 6 for cooling the target assembly 1.

[ 0059]        Specifically, the target assembly 1 may be detachably installed in the clamping groove. Multiple target assemblies 1 may be presented and one skilled in the art may disassemble and replace the target assembly 1 by himself, selecting a target assembly 1 with required inclination angles and the target assembly 1 of required materials, and installing it into the clamping groove of the mounting seat 7.

[ 0060]        As heat is generated when an electron beam 9 acts on a first target 2 or a second target 4, in order to guarantee the normal operation of the first target 2 or the second target 4, it is necessary to ensure the heat dissipation of the first target 2 or the second target 4. The mounting seat 7 is provided with the cooling assembly 6 for cooling the target assembly 1.

[ 0061]        When an electron beam 9 acts on a first target 2 or a second target 4, heat is generated, and transferred to the first heat dissipating layer 3 or the second heat dissipating layer 5, and then transferred to the mounting seat 7 through the first heat dissipating layer 3 or the second heat dissipating layer 5. The mounting seat 7 is provided with the cooling assembly 6, which transfers the heat from the mounting seat 7 away.

[ 0062]        Furthermore, the mounting seat 7 includes a first cooling side plate 701, a second cooling side plate 702, a cooling bottom plate 703 and a cooling back plate 704. The cooling assembly 6 includes a first cooling coil 601, a second cooling coil 602, a third cooling coil 603 and a fourth cooling coil 604. The inner cavity of the first cooling side plate 701 is provided with the first cooling coil 601, the inner cavity of the second cooling side plate 702 is provided with the second cooling coil 602, the inner cavity of the cooling bottom plate 703 is provided with the third cooling coil 603, and the inner cavity of the cooling back plate 704 is provided with the fourth cooling coil 604.

[ 0063]        The mounting seat 7 may be integrally formed with the first cooling side plate 701, the second cooling side plate 702, the cooling bottom plate 703 and the cooling back plate 704, or may be assembled with them.

[ 0064]        The inner cavity of the first cooling side plate 701 is provided with the first cooling coil 601, the inner cavity of the second cooling side plate 702 is provided with the second cooling coil 602, the inner cavity of the cooling bottom plate 703 is provided with the third cooling coil 603, and the inner cavity of the cooling back plate 704 is provided with the fourth cooling coil 604.

[ 0065] In some embodiments, the first cooling coil 601, the second cooling coil 602, the third cooling coil 603 and the fourth cooling coil 604 are connected end to end, and a liquid inlet is provided at one end and a liquid outlet is provided at the other end. A coolant enters the liquid inlet, passes through the first cooling coil 601, the second cooling coil 602, the third cooling coil 603 and the fourth cooling coil 604 in sequence, and is discharged from the liquid outlet. The coolant takes away the heat of the first cooling side plate 701, the second cooling side plate 702, the cooling bottom plate 703 and the cooling back plate 704 in sequence, dissipating heat for the mounting seat 7, thereby indirectly dissipating heat for the target assembly 1.

[ 0066] In some embodiments, one end of the first cooling coil 601 is a liquid inlet and the other end of the first cooling coil 601 is a liquid outlet. The coolant enters from the liquid inlet, passes through the first cooling coil 601, and is discharged from the liquid outlet. The coolant takes away the heat of the first cooling side plate 701, only dissipating heat for the first cooling side plate 701.

[ 0067] One end of the second cooling coil 602 is a liquid inlet and the other end of the second cooling coil 602 is a liquid outlet. The coolant enters the liquid inlet, passes through the second cooling coil 602, and is discharged from the liquid outlet. The coolant takes away the heat of the second cooling side plate 702, only dissipating heat for the second cooling side plate 702.

[ 0068] One end of the third cooling coil 603 is a liquid inlet and the other end of the third cooling coil 603 is a liquid outlet. The coolant enters the liquid inlet, passes through the third cooling coil 603, and is discharged from the liquid outlet. The coolant takes away the heat of the cooling bottom plate 703, only dissipating heat for the cooling bottom plate 703.

[ 0069] One end of the fourth cooling coil 604 is a liquid inlet and the other end of the fourth cooling coil 604 is a liquid outlet. The coolant enters the liquid inlet, passes through the fourth cooling coil 604, and is discharged from the liquid outlet. The coolant takes away the heat of the cooling back plate 704, only dissipating heat for the cooling back plate 704.

[ 0070] It should be noted that the coolant is preferably water, or may be a type of coolant commonly used in the art, and one skilled in this art can choose the type of

coolant according to the need.

[ 0071] As shown in FIGs. 1 to 4, the X-ray microscope provided by the embodiment of the disclosure includes an electron optical column 8, a sample stage 14, a vacuum chamber 10, and an X-ray detector 17.

[ 0072] The electron optical column 8 is configured to emit an electron beam 9, and the lower end of the electron optical column 8 is connected with the vacuum chamber 10. The vacuum chamber 10 is provided with a vacuum window 15.

[ 0073] The sample table 14 is configured to place a sample to be tested 13 and arranged in the vacuum chamber 10.

[ 0074] The target assembly 1 is located in the vacuum chamber 10. The electron beam 9 acts on the target assembly 1, and generates the X-ray 12, which irradiates the sample 13 to be tested, passes through the vacuum window 15, and is received by the X-ray detector 17.

[ 0075] Specifically, the electron optical column 8 is configured to generate the electron beam 9 and emits the scanning electron beam 9. The electron optical column 8 includes an electron source 801, an electron accelerating structure 802 and an object lens system 803.

[ 0076] The electron source 801 is used for generating and emitting the electron beam 9. The electron accelerating structure 802 is an anode, and is configured to form an electric field along the emitting direction of the electron beam 9 to increase the movement speed of the electron beam 9.

[ 0077] The object lens system 803 is configured to control the beam size and the advancing direction of the electron beam 9 emitted by the electron source 801.

[ 0078] The object lens system 803 includes an object lens and a deflecting device. The object lens may be a magnetic lens, an electrolens, or an electromagnetic complex lens. The deflecting device may be a magnetic deflecting device or an electric deflecting device. The deflecting device is used for changing the movement direction of the electron beam 9 emitted by the electron source 801, and can generate a scanning field with any deflecting direction.

[ 0079] As shown in FIGs. 1 to 4, the X-ray microscope provided by the embodiment of the disclosure includes, from the top to the bottom, the electron optical column 8 , the vacuum chamber 10 connected with the lower end of the electron optical lens cone 8 , and the sample stage 14 arranged in the vacuum chamber 10 for placing the sample 13 to be tested. The sample stage 14 is arranged in the vacuum chamber 10, and the vacuum chamber 10 is provided with the vacuum window 15.

[ 0080] The sample stage 14 is capable of a movement with five degrees of freedom, including three-dimensional translation (translation in three directions of X, Y and Z), rotation (R) around its central axis and tilt (T). The sample stage 14 can drive the sample to be tested 13 to move in the vacuum chamber 10 with the five degrees of freedom.

[ 0081] As shown in FIGs. 1 to 4, the X-ray microscope provided by the embodiment of the disclosure further includes a manipulator 11, which is configured to clamp the target assembly 1 to move in the vacuum chamber 10. The manipulator 11 is capable of a movement with six degrees of freedom. The manipulator 11 is configured to clamp the target assembly 1 and is able to control the target assembly 1 to move linearly and rotationally in the vacuum chamber 10.

[ 0082] The vacuum chamber 10 is provided with the vacuum window 15. The X-ray detector 17 is provided outside the vacuum chamber 10, at a position corresponding to the vacuum window 15. The electron beam 9 generated by the electron optical column 8 acts on the target assembly 1 to generate the X-ray 12. The X-ray 12 irradiates on the sample to be tested 13, then passes through the vacuum window 15, and is received by the X-ray detector 17.

[ 0083] As shown in FIGs 1 to 4, in some embodiments, the X-ray microscope provided by the embodiment of the disclosure includes a bellows 16, one end of which is connected to the X-ray detector 17, and the other end of which is connected to an outer sidewall of the vacuum chamber 10 around the vacuum window 15.

[ 0084] Specifically, the X-ray detector 17 is capable of the movement with five degrees of freedom, including three-dimensional translation (translation in three directions of X, Y and Z), rotation (R) around its central axis, and a tilt (T). The X-ray detector 17 is connected with the outer sidewall of the vacuum chamber 10 around the vacuum window 15 through the bellows 16, and is capable of the movement with five

degrees of freedom, therefore the X-ray detector 17 can be flexibly adjusted its positional relationship with respect to the vacuum window 15.

[ 0085]        Furthermore, a sealed chamber is enclosed by the outer sidewall of the vacuum chamber 10, the bellows 16, the X-ray detector 17 and the vacuum window 15, and helium or nitrogen is filled into the sealed chamber.

[ 0086]        The X-ray detector 17 is connected with the outer sidewall of the vacuum chamber 10 around the vacuum window 15 by the bellows 16, thus the sealed chamber is defined by the outer sidewall of the vacuum chamber 10, the bellows 16, the X-ray detector 17 and the vacuum window 15. Filling helium or nitrogen into the sealed chamber can reduce the attenuation of transmission of the X-ray 12, thereby improving the signal-to-noise ratio of the X-ray microscope.

[ 0087]        As shown in FIGs. 1 to 4, the X-ray microscope provided by embodiments of the disclosure is illustrated with a specific embodiment. The target assembly 1 is integrally formed of the first section 101 and the second section 102, the first heat dissipating layer 3 and the second heat dissipating layer 5 are integrally formed, and both the first heat dissipating layer 3 and the second heat dissipating layer 5 are made of diamond.

[ 0088]        The target assembly 1 is provided with six first targets 2 and one second target 4. In the direction from the first targets 2 to the second target 4, the inclination angles of the first action surfaces 201 of the first one, the second one, the third one, the fourth one, the fifth one and the sixth one of the first targets 2 are 20 degrees, 25 degrees, 30 degrees, 35 degrees, 40 degrees and 45 degrees, respectively. The second action surface 401 of the second target 4 is in parallel with the bottom surface of the second groove 501.

[ 0089]        The material of the first one to the third one of the first targets 2 is manganese, and the material of the fourth one to the fifth one of the first targets 2 is chrome, and the materials of the sixth one of the first targets 2 and the second target 4 are tungsten.

[ 0090]        The target assembly 1 is clamped in the clamping groove of the mounting seat 7, and the mounting seat 7 is provided with the cooling assembly 6 for cooling the target assembly 1. The manipulator 11 is configured to clamp the target assembly 1 through the mounting seat 7, and is able to control the target assembly 1 to move in the vacuum

chamber 10 with six degrees of freedom. The electron beam 9 generated by the electron optical column 8 acts on the target assembly 1 to generate the X-ray 12, which irradiates on the sample, then passes through the vacuum window 15, and is received by the X-ray detector 17.

[ 0091]        Specifically, the electron beam 9 generated by the electron optical column 8 may selectively act on any one of the first action surfaces 201 of the first targets 2 or the second action surface 401.

[ 0092]        The straight line movement of the target assembly 1 may be controlled with the manipulator 11, thereby driving the first action surfaces 201 with different inclination angles to move, and one first action surface 201 with the required inclination angle or the second action surface 401 may be selected and move straightly to the position below the electron beam 9, thereby controlling and adjusting the emission direction of the generated X-ray 12 beam of the high density X-ray 12 area. In this way, the X-ray 12 density in the effective irradiation area is increased and the imaging quality of an X-ray microscope is improved.

[ 0093]        Because the material of the first to third ones of the first targets 2 is manganese, and the material of the fourth and fifth ones of the first targets 2 is chrome, and the material of the sixth one of the first targets 2 and the second target 4 is tungsten. It is also possible to control the linear movement of the target assembly 1 by the manipulator 11, driving the first action surfaces 201 of different materials to move, and one first action surface 201 with the required material or the second action surface 401 may be selected and move straightly to the position below the electron beam 9. Therefore, the first targets 2 or the second target 4 made of different materials are adjusted to be acted by the electron beam 9, and then different X-rays 12 are generated to irradiate the sample to be tested 13.

[ 0094]        The sample stage 14 is configured to drive the sample to be tested 13 to move in the vacuum chamber 10 with five degrees of freedom. The sample to be tested 13 is driven by the sample stage 14 to change its spatial position in the vacuum chamber 10. For example, if the sample to be tested 13 rotates for one revolution in the vacuum chamber 10, the X-ray 12 can irradiate the sample to be tested 13 for one revolution. The vacuum chamber 10 is provided with the vacuum window 15 which may be a beryllium

window or a glass window. At a position outside the vacuum chamber 10, corresponding to the vacuum window 15, the X-ray detector 17 is provided. The generated X-ray 12 irradiates on the sample to be tested 13, then passes through the vacuum window 15, and is received by the X-ray detector 17. Since the X-ray detector 17 is capable of a movement with five degrees of freedom, the X-ray detector 17 can be flexibly adjusted the positional relationship with respect to the vacuum window 15. Therefore, the X-ray 12 can be better received by the x-ray detector 17.

[ 0095]        Furthermore, the X-ray detector 17 is connected with the outer sidewall of the vacuum chamber 10 around the vacuum window 15 by the bellows 16. A sealed chamber is defined by the outer sidewall of the vacuum chamber 10, the bellows 16, the X-ray detector 17 and the vacuum window 15, and helium or nitrogen is filled into the sealed chamber. In addition, the X-ray detector 17 is capable of the movement with five degrees of freedom, thus it can be flexibly adjusted its positional relationship with respect to the vacuum window 15. The x-ray detector 17 can better receive the X-ray 12.

[ 0096]        The X-ray detector 17 is connected with the outer sidewall of the vacuum chamber 10 around the vacuum window 15 by the bellows 16. The sealed chamber is enclosed by the outer sidewall of the vacuum chamber, the bellows 16, the X-ray detector 17 and the vacuum window 15. Filling helium or nitrogen into the sealed chamber can reduce the attenuation of transmission of the X-ray 12, thereby improving the signal-to-noise ratio of an X-ray microscope.

[ 0097]        The above are only preferred embodiments of the disclosure, and do not limit the disclosure in any form. Although the disclosure has been disclosed with the preferred embodiments, they are not intended to limit the disclosure. Any skilled person who is familiar with the disclosure may make equivalent embodiments with some changes or modifications of equivalent replacements by using the technical contents suggested above without departing from the scope of the technical solution of the disclosure. However, any content without departing from the scope of the technical solution of the disclosure and any simple modification, equivalent replacement and modification made to the above embodiments according to the technical essence of the present disclosure still fall within the scope of the present disclosure.

## CLAIMS

### 1. A target assembly, comprising:

a first section comprising a first heat dissipating layer, wherein the first heat dissipating layer is provided with at least two first grooves, each of the at least two first grooves is provided with one first target, each of the at least two first targets is provided with one first action surface that is configured to be acted by an electron beam, each of the at least two first action surfaces is arranged to be inclined with respect to a bottom surface of a respective one of the at least two first grooves, and inclination angles of the at least two first action surfaces are different; and

a second section comprising a second heat dissipating layer, wherein the second heat dissipating layer is provided with a second groove, a second target is arranged in the second groove, the second target is provided with a second action surface that is configured to be acted by the electron beam, and the second action surface is arranged parallel to a bottom surface of the second groove.

2. The target assembly according to claim 1, wherein materials of the at least two first targets are different, and wherein the second heat dissipating layer is provided with at least two second grooves, at least two second targets are respectively arranged in the at least two second grooves, and materials of the at least two second targets are different.

3. An X-ray microscope, comprising the target assembly according to claim 1 or 2, wherein the X-ray microscope comprises a mounting seat provided with a clamping groove, the target assembly is detachably installed in the clamping groove, and the mounting seat is provided with a cooling assembly for cooling the target assembly.

4. The X-ray microscope according to claim 3, wherein the mounting seat comprises a first cooling side plate, a second cooling side plate, a cooling bottom plate and a cooling back plate;

the cooling assembly comprises a first cooling coil, a second cooling coil, a third cooling coil and a fourth cooling coil; and

an inner cavity of the first cooling side plate is provided with the first cooling coil, an inner cavity of the second cooling side plate is provided with the second cooling coil, an inner cavity of the cooling bottom plate is provided with the third cooling coil, and an inner cavity of the cooling back plate is provided with the fourth cooling coil.

5. The X-ray microscope according to claim 3, further comprising:

an electron optical column, configured to emit an electron beam, a lower end of the electron optical column being connected with a vacuum chamber provided with a vacuum window; and

a sample stage, configured to place a sample to be tested and arranged in the vacuum chamber,

wherein the target assembly is located in the vacuum chamber, the target assembly is acted by the electron beam to generate an X-ray, which irradiates the sample to be tested, passes through the vacuum window, and is received by an X-ray detector.

6. The X-ray microscope according to claim 5, further comprising a manipulator, configured to clamp the target assembly to move in the vacuum chamber.

7. The X-ray microscope according to claim 5, further comprising a bellows, wherein an end of the bellows is connected with the X-ray detector, and another end of the bellows is connected with an outer sidewall of the vacuum chamber around the vacuum window.

8. The X-ray microscope according to claim 7, wherein a sealed chamber is defined by the outer sidewall of the vacuum chamber, the bellows, the X-ray detector and the vacuum window, and the sealed chamber is filled with helium or nitrogen.