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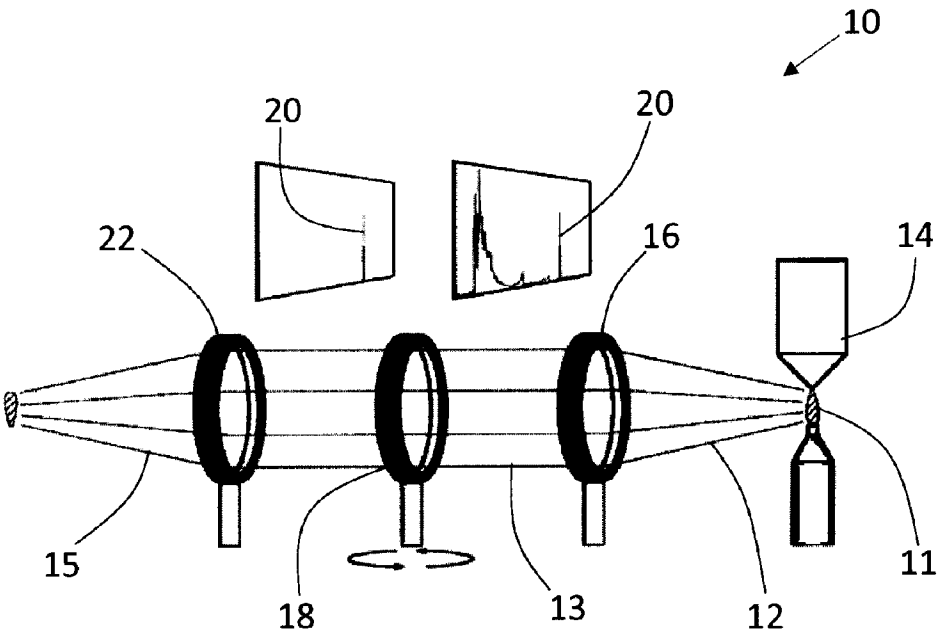
(54) Titre : SYSTEME ET METHODE POUR DETECTER DES LIGNES D`EMISSION ELEMENTAIRE UNIQUES DANS UNE DECHARGE LUMINESCENTE

(54) Title: A SYSTEM AND METHOD FOR DETECTING SINGLE ELEMENTAL EMISSION LINES IN A GLOW DISCHARGE



(57) Abrégé/Abstract:
A system and method for detecting single elemental emission lines in a glow discharge. A glow discharge emits a light. At least a portion of the light travels to a bandpass filter. The bandpass filter is rotatable between a first angle and a second angle. The first angle is offset from the direction of travel of the at least a portion of light traveling from the glow discharge such that an emission line of interest passes through the bandpass filter. The second angle blocks the emission line of interest and allows at least a portion of light traveling from the glow discharge that has a longer or a shorter wavelength than the emission line to pass through the bandpass filter.

ABSTRACT

A system and method for detecting single elemental emission lines in a glow discharge. A glow discharge emits a light. At least a portion of the light travels to a bandpass filter. The bandpass filter is rotatable between a first angle and a second angle. The first angle is offset from the direction of travel of the at least a portion of light traveling from the glow discharge such that an emission line of interest passes through the bandpass filter. The second angle blocks the emission line of interest and allows at least a portion of light traveling from the glow discharge that has a longer or a shorter wavelength than the emission line to pass through the bandpass filter.

TITLE

[0001] A System and Method for Detecting Single Elemental Emission Lines in a Glow Discharge

FIELD OF THE DISCLOSURE

[0002] The present application relates generally to system and method for detecting emission lines in a glow discharge.

BACKGROUND

[0003] This section provides background information to facilitate a better understanding of the various aspects of the invention. It should be understood that the statements in this section of this document are to be read in this light, and not as admissions of prior art.

[0004] Currently, SCGD and SAGD measurements are performed with the use of a dispersive optical element, such as the diffraction grating in a spectrometer or monochromator. This allows for the light emitted by the glow discharge to be separated into a spectrum, wherein the intensity at a certain wavelength can be related to the concentration of a particular element or molecular species in the analyte. Spectrometers and monochromators add to the complexity, size and expense of an SCGD/SAGD device.

BRIEF SUMMARY

[0005] There is provided a system for detecting single elemental emission lines in a glow discharge. A glow discharge emits a light. At least a portion of the light travels to bandpass filter. The bandpass filter rotates between a first angle and a second angle. The first angle is offset from the direction of travel of the at least a portion of the light that travels to the bandpass filter such that an emission line of interest passes through the bandpass filter. The second angle blocks the emission line of interest and allows the at least a portion of the light that travels to the bandpass filter having a longer or a shorter wavelength than the emission line of interest to pass through the bandpass filter.

[0006] In one embodiment a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge is positioned between the glow discharge and the bandpass filter such that light is collimated prior to traveling to the bandpass filter.

[0007] In one embodiment, a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the bandpass filter.

[0008] In one embodiment, a dispersive element is provided for spectral discrimination. The dispersive element may be a diffraction grating in a spectrometer or monochromator or any other dispersive element known to a person skilled in the art.

[0009] In one embodiment, a fibre optic cable is provided for passing the light to an analyzing device such as a spectrometer or monochromator or device for measuring total light intensity. or any other analyzing device known to a person skilled in the art.

[0010] In one embodiment, the bandpass filter is rotated between the first angle and the second angle manually.

[0011] In another embodiment, the rotation of the bandpass filter between the first angle and the second angle is automated.

[0012] In one embodiment, the bandpass filter is positioned on a rotating stage.

[0013] There is also provided a method for detecting single elemental emission lines in a glow discharge. A glow discharge is activated to create a light. At least a portion of the light from the glow discharge travels to the bandpass filter. The bandpass filter is provided that is rotatable between a first angle and a second angle. The first angle is offset from a direction of travel of the at least a portion of the light travelling to the bandpass filter such that an emission line of interest passes through the bandpass filter. The second angle blocks the emission line of interest and allows the at least a portion of the light travelling to the bandpass filter that has a longer or a shorter wavelength than the emission line of interest to pass through the bandpass filter. The at least a portion of the light travelling to the bandpass filter is passed through the bandpass filter positioned at the first angle and at least one first data point is recorded. The at least a portion of the light travelling to the bandpass filter is passed

through the bandpass filter positioned at the second angle and at least one second data point is recorded. The at least one first data point and the at least one second data point are analyzed.

[0014] In one embodiment, a further step includes collimating at least a portion of the light from the glow discharge in a first collimating component to create a collimated light prior to the light passing through the bandpass filter.

[0015] In one embodiment, the light that passes through the bandpass filter is recollimated after the at least one first data point and the at least one second data point are required.

[0016] In one embodiment, after the light is recollimated, a spectral discrimination analysis may be completed.

[0017] In one embodiment, a fibre optic cable is provided for passing the recollimated light to an analyzing device such as a spectrometer or monochromator. The light may also be analyzed by measuring total light intensity.

[0018] In one embodiment, the bandpass filter is rotated between the first angle and the second angle manually.

[0019] In another embodiment, the rotation of the bandpass filter between the first angle and the second angle is automated.

[0020] In one embodiment, the bandpass filter is positioned on a rotating stage.

[0021] There is also provided a system for detecting single elemental emission lines in a glow discharge. A glow discharge emits a light. A first bandpass filter is positioned at a first angle. The first angle is offset from the direction of travel of the at least a portion of the light that travels from the glow discharge such that an emission line of interest passes through the bandpass filter. A second bandpass filter is positioned at a second angle. The second angle is offset from the direction of travel of the at least a portion of the light that travels from the glow discharge such that the at least a portion of the that travels from the glow discharge that has a longer or a shorter wavelength than the emission line of interest passes through the second bandpass filter and the emission line of interest is blocked.

[0022] In one embodiment, a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge is positioned between the glow discharge and the first bandpass filter such that light is collimated prior to traveling to the first bandpass filter.

[0023] In one embodiment, a second optical collimating component for collimating at least a portion of the light emitted from the glow discharge is positioned between the glow discharge and the second bandpass filter such that light is collimated prior to traveling to the second bandpass filter.

[0024] In one embodiment, a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the first bandpass filter. A second lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the second bandpass filter.

[0025] In one embodiment, a dispersive element is provided for spectral discrimination. The dispersive element may be a diffraction grating in a spectrometer or monochromator or any other dispersive element known to a person skilled in the art.

[0026] In one embodiment, a fibre optic cable is provided for passing the light to an analyzing device such as a spectrometer or monochromator or device for measuring total light intensity. or any other analyzing device known to a person skilled in the art.

[0027] There is also provided a system for detecting single elemental emission lines in a glow discharge. A glow discharge emits a light. At least a portion of the light travels to a first bandpass filter or a second bandpass filter. The first bandpass filter allows at least a portion of the light traveling from the glow discharge to pass through the first bandpass filter such that an emission line of interest passes through the first bandpass filter. A second bandpass filter is interchangeable with the first bandpass filter. The second bandpass filter allowing at least a portion of the traveling from the glow discharge to pass through the bandpass filter such that the emission line of interest is blocked and the at least a portion of the light that has a longer or shorter wavelength than the emission line of interest to pass through the second bandpass filter.

18. The system of claim 17 further comprising a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the first bandpass filter such that light is collimated prior to traveling to the first bandpass filter.

19. The system of claim 17 further comprising a second optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the second bandpass filter such that light is collimated prior to traveling to the second bandpass filter.

[0028] In one embodiment, a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge is provided. The first optical collimating component is positioned between the glow discharge and the first bandpass filter and the second bandpass filter such that light is collimated prior to traveling to the first bandpass filter and the second bandpass filter. At least a portion of the light travels to the first optical collimating component and the second optical collimating component. The first optical collimating component and the second optical collimating component collimate at least a portion of the light emitted from the glow discharge.

[0029] In one embodiment, a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the first bandpass filter or the second bandpass filter.

[0030] In one embodiment, a dispersive element is provided for spectral discrimination. The dispersive element may be a diffraction grating in a spectrometer or monochromator or any other dispersive element known to a person skilled in the art.

[0031] In one embodiment, a fibre optic cable is provided for passing the light to an analyzing device such as a spectrometer or monochromator or device for measuring total light intensity or any other analyzing device known to a person skilled in the art.

[0032] In one embodiment, the first bandpass filter and the second bandpass filter are switched automatically.

[0033] In one embodiment, at least one of the first bandpass filter and the second bandpass filter is rotatable to an angle different from the other of the first bandpass filter or the second bandpass filter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] These and other features will become more apparent from the following description in which references are made to the following drawings, in which numerical references denote like parts. The drawings are for the purpose of illustration only and are not intended to in any way limit the scope of the invention to the particular embodiments shown.

[0035] FIG. 1 is a schematic view of a system for detecting single elemental emission lines in a glow discharge.

[0036] FIG. 2 is a graph showing data points of wavelengths passing through the bandpass filter.

[0037] FIG. 3 is a perspective view of the bandpass filter.

[0038] FIG. 4 is a schematic view of the system for detecting single elemental emission lines in a glow discharge.

[0039] FIG. 5 is a schematic view of the system for detecting single elemental emission lines in a glow discharge with a fibre optic cable and analyzing device.

[0040] FIG. 6 is a schematic view of a variation of the system for detecting single elemental emission lines in a glow discharge.

[0041] FIG. 7 is a schematic view of the variation of the system for detecting single elemental emission lines in a glow discharge with a fibre optic cable and analyzing device.

[0042] FIG. 8 is a schematic view of a second variation of the system for detecting single elemental emission lines in a glow discharge.

[0043] FIG. 9 is a schematic view of the second variation of the system for detecting single elemental emission lines in a glow discharge with a fibre optic cable and analyzing device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0044] A system for detecting single elemental emission lines in a glow discharge, generally identified by reference numeral 10, will now be described with reference to FIG. 1 through FIG. 5.

[0045] Referring to **FIG. 1**, system 10 is designed to detect single elemental emission lines in a glow discharge. Light 12 is emitted from a glow discharge apparatus 14 such as a solution cathode glow discharge (SCGD) apparatus, or a solution anode glow discharge (SAGD) apparatus, an electrolyte

cathode glow discharge (ELCAD) apparatus or any other glow discharge based apparatus. At least a portion of light 12 travels to a bandpass filter 18. Bandpass filter 18 is designed to allow a particular range of wavelengths to pass through and block other wavelengths. Bandpass filter 18 is rotatable between a first angle and a second angle. The first angle is offset from the direction of travel of at least a portion of light 12 traveling to bandpass filter 18. In order to pass the desired band of frequencies through bandpass filter 18, bandpass filter 18 should be at the designed angle to the incident light. Generally, the first angle is 90 degrees from the direction of travel of at least a portion of light 12, however it will be understood by a person skilled in the art that first angle may be different as long as it allows for the capture of a portion of light 12. The second angle blocks emission line of interest 20 but allows at least a portion of light 12 that has a longer or a shorter wavelength than emission line of interest 20 to pass through bandpass filter 18. By rotating bandpass filter 18 away from the design angle, frequencies will be higher or lower than the design frequencies. The direction of rotation will determine whether higher or lower frequencies pass through bandpass filter 18. The second angle is dependent on the design of bandpass filter 18. Second angle should be such that the emission line of interest 20 is no longer detected and a different band, shown in **FIG. 2** as reference numeral 21, is detected. This different band should be chosen such that no emission line from other elements in the sample are analyzed. In some cases, this will be a higher frequency and in other cases it will be a lower frequency. Second angle is specific to the element to be detected and other elements that may be present in light 12. A person of skill will be able to determine a suitable second angle for each sample to be tested. By choosing a second angle that has no line from other elements, only random noise generated by equipment will be detected. Removing this noise during analysis leaves you with the emission line of interest 20. Bandpass filter 18 may be rotated manually or rotation may be automated. Referring to **FIG. 3**, bandpass filter 18 may be positioned on a rotating stage 23 to assist in rotation of bandpass filter 18.

[0046] A first optical collimating component 16 is provided for collimating at least a portion of light 12 from glow discharge 14 to collimated light 13. When first optical collimating component 16 is used, first angle of bandpass filter 18 is offset from the direction of travel of collimated light 13 such that an emission line of interest 20 passes through bandpass filter 18. Generally, the first angle is 90 degrees from the direction of travel of collimated light 13, however it will be understood by a person skilled in the art that first angle may be different as long as it allows for the capture of a portion of collimated light 13. The second angle blocks emission line of interest 20 but allows at least a portion of collimated

light 13 that has a longer or a shorter wavelength than emission line of interest 20 to pass through bandpass filter 18.

[0047] Referring to **FIG. 4**, a lens 22 is provided for reforming at least a portion of light 12 or collimated light 13 as reformed light 15 after it has passed through bandpass filter 18. Lens 22 may be a plano-convex lens or may include two plano-convex lenses such that light is collimated and then flipped and focused. The reformed light 15 may be analyzed by an analyzing device 24 such as a spectrometer, monochromator, photomultiplier tube, photodiodes or any other analyzing device or other dispersive element known to a person skilled in the art for spectral discrimination.

[0048] Referring to **FIG. 5**, a fibre optic cable 26 may be provided for passing reformed light 15 to analyzing device 24 such as a spectrometer or monochromator. Lens 22 reforms the light to correspond to the image of the plasma created by glow discharge apparatus 14. When light is reformed, it may reform the image of plasma 11 created by glow discharge apparatus 14 in a 1:1 ratio or some other ratio as may be determined by someone skilled in the art. This allows fibre optic cable 26 to be placed in a specific location within reformed light 15 to maximize the signal of the desired element and minimize as much as possible of others. The positioning of fibre optic cable will be understood by a person skilled in the art.

[0049] Detection of a single elemental emission line from a glow discharge can occur by utilizing a rotatable bandpass filter 18 in association with a first collimating component 16. Glow discharge apparatus 14 is activated to create a light 12 that will be analyzed. At least a portion of light 12 travels to and through bandpass filter 18. Bandpass filter 18 is positioned at a first angle which is offset from a direction of travel of at least a portion of light 12 such that emission line of interest 20 passes through bandpass filter 18. At least one first data point 19, shown in **FIG. 2**, is recorded based on light 12 passing through bandpass filter 18. Bandpass filter 18 is rotated to a second angle that blocks emission line of interest 20 from passing through bandpass filter 18 but allows light 12 that has a longer or a shorter wavelength than emission line of interest 20 to pass through bandpass filter 18. Light 12 passes through bandpass filter 18 at the second angle and at least one second data point 21, shown in **FIG. 2**, is recorded. Referring to **FIG. 2**, the at least one first data point 19 and the at least one second data point 21 are analyzed to detect a single elemental emission line. Using the at least one first data point 19 and the at least one second data point 21, the emission intensity that originates from element of interest 20 can be determined. The at least one first data point 19 corresponds to a coincident with the atomic

emission line. The at least one second data point 21 corresponds to a sampling of the nearby continuum.

[0050] Prior to passing through bandpass filter 18, at least a portion of light 12 from glow discharge apparatus 14 may be collimated by first collimating component 16 to create collimated light 13. Collimated light 13 travels to and through bandpass filter 18. When first collimating component 16 is present, bandpass filter 18 is positioned at a first angle which is offset from a direction of travel of collimated light 13 such that emission line of interest 20 passes through bandpass filter 18. Second angle of bandpass filter 18 blocks emission line of interest 20 from passing through bandpass filter 18 but allows collimated light 13 that has a longer or a shorter wavelength than emission line of interest 20 to pass through bandpass filter 18.

[0051] After light 12 or collimated light 13 has passed through bandpass filter 18, it may be reformed to reformed light 15 by a lens 22. Lens 22 may be a plano-convex lens or may include two plano-convex lenses such that light is collimated and then flipped and focused. Reforming can be completed when spatial discrimination of light 12 emitted from glow discharge apparatus 16 is desired or the totality of light 12 is being analyzed if spatial discrimination is not desired. Reformed light 15 may be analyzed by an analyzing device 24 that has a dispersive element for spectral discrimination such as a spectrometer or monochromator. Total light intensity may also be analyzed. Referring to **FIG. 4**, analyzing device 24 may simply respond to the integrated intensity that is incident upon it such as photomultiplier tube or photodiodes. Referring to **FIG. 5**, reformed light 15 may be analyzed directly or passed into analyzing device through a fibre optic cable 26.

[0052] Optical collimating components may be collimating lens or any other collimating component known to a person skilled in the art. A lens may be useful in gathering as much light as possible. High concentrations of light may not require the use of an optical collimating component positioned in front of bandpass filter 18.

[0053] A system for detecting single elemental emission lines in a glow discharge, generally identified by reference numeral 100, will now be described with reference to FIG. 6 through FIG. 7.

[0054] Referring to **FIG. 6**, system 100 is designed to detect single elemental emission lines in a glow discharge. Light 12 is emitted from a glow discharge apparatus 104 such as a solution cathode glow

discharge (SCGD) apparatus, or a solution anode glow discharge (SAGD) apparatus, an electrolyte cathode glow discharge (ELCAD) apparatus or any other glow discharge based apparatus. A first bandpass filter 108 is provided. First bandpass filter 108 is positioned at a first angle. First angle is offset from the direction of travel of at least a portion of light 12 traveling to first bandpass filter 108 such that an emission line of interest pass through first bandpass filter 108. A second bandpass filter 109 is positioned at a second angle. The second angle is offset from the direction of travel of at least a portion of light 12 traveling to second bandpass filter 109 such that at least a portion of collimated light 13b that has a longer or a shorter wavelength than emission line of interest 20 passes through second bandpass filter 109. Second angle of second bandpass filter 109 blocks emission line of interest 20.

[0055] Prior to passing through first bandpass filter 108, at least a portion of light 12 travels to a first optical collimating component 106 and a second optical collimating component 107. First optical collimating component 106 collimates at least a portion of light 12 from glow discharge 104 to collimated light 13a. When first optical collimating component 106 is present, first angle is offset from the direction of travel of the at least a portion of collimated light 13a from first optical collimating component 106 such that an emission line of interest pass through first bandpass filter 108. Prior to passing through second bandpass filter 109, second optical collimating component 107 collimates at least a portion of light 12 from glow discharge apparatus 104 to collimated light 13b. When second optical collimating component 107 is present, the second angle is offset from the direction of travel of collimated light 13b such that at least a portion of collimated light 13b that has a longer or a shorter wavelength than emission line of interest 20 passes through second bandpass filter 109. Second angle of second bandpass filter 109 blocks emission line of interest 20.

[0056] First bandpass filter 108 and second bandpass filter 109 are designed to allow a particular range of wavelengths to pass through and block other wavelengths. The second angle is dependent on the design of first bandpass filter 108 and second bandpass filter 109. Second angle should be such that the emission line of interest 20 is no longer detected and a different band, shown in **FIG. 2** as reference numeral 21, is detected. This different band should be chosen such that no emission line from other elements in the sample are analyzed. In some cases, this will be a higher frequency and in other cases it will be a lower frequency. Second angle is specific to the element to be detected and other elements that may be present in the collimated light 13a and 13b. A person of skill will be able to determine a suitable second angle for each sample to be tested. By choosing a second angle that has no line from

other elements, only random noise generated by equipment will be detected. Removing this noise during analysis leaves you with the emission line of interest 20.

[0057] A lens 122 is provided for reforming at least a portion of light 13a as reformed light 15a after it has passed through first bandpass filter 108. A second lens 123 is provided for reforming at least a portion of light 13b as reformed light 15b after it has passed through second bandpass filter 109. Lens 122 and second lens 123 may be plano-convex lens or may include two plano-convex lenses such that light is collimated and then flipped and focused. The reformed light 15b may be analyzed by an analyzing device 24 such as a spectrometer, monochromator, photomultiplier tube, photodiodes or any other analyzing device or other dispersive element known to a person skilled in the art for spectral discrimination. Total light intensity may also be analyzed.

[0058] Referring to **FIG. 7**, a fibre optic cable 26 may be provided for passing reformed light 15a or 15b to analyzing device 24 such as a spectrometer or monochromator. Lens 122 and second lens 123 reforms the light to correspond to the image of the plasma created by glow discharge apparatus 104. When light is reformed, it may reform the image of plasma 11 created by glow discharge apparatus 104 in a 1:1 ratio or some other ratio as may be determined by someone skilled in the art. This allows fibre optic cable 26 to be placed in a specific location within reformed light 15a or 15b to maximize the signal of the desired element and minimize as much as possible of others. The positioning of fibre optic cable 26 will be understood by a person skilled in the art.

[0059] It will be understood by a person skilled in the art that light passing through first bandpass filter 108 and second bandpass filter 109 may be treated differently. For example, light passing through first bandpass filter 108 may be reformed to reformed light 15a which is analyzed by analyzing device 24 while light passing through second bandpass filter 109 is allowed to dissipate. Light passing through first bandpass filter 108 may be reformed to reformed light 15a which is transmitted by fibre optic cable 26 to analyzing device 24 while light passing through second bandpass filter 109 is reformed to reformed light 15b which is directly analyzed by analyzing device 24.

[0060] A system for detecting single elemental emission lines in a glow discharge, generally identified by reference numeral 200, will now be described with reference to FIG. 8 through FIG. 9.

[0061] Referring to **FIG. 8**, system 200 is designed to detect single elemental emission lines in a glow discharge. Light 12 is emitted from a glow discharge apparatus 204 such as a solution cathode glow discharge (SCGD) apparatus, or a solution anode glow discharge (SAGD) apparatus, an electrolyte cathode glow discharge (ELCAD) apparatus or any other glow discharge based apparatus. At least a portion of light 12 travels to a first bandpass filter 208 or a second bandpass filter 209. First bandpass filter 208 is designed to allow a particular range of wavelengths to pass through and block other wavelengths. First bandpass filter 208 is offset from the direction of travel of at least a portion of light 12 traveling to first bandpass filter 208 such that an emission line of interest 20 passes through first bandpass filter 208. In order to pass the desired band of frequencies through bandpass filter 18, bandpass filter 18 should be at the designed angle to the incident light. Second bandpass filter 209 is interchangeable with first bandpass filter 208. First bandpass filter 208 and second bandpass filter 209 can be switched manually or automatically. Second bandpass filter 209 allows at least a portion of light 12 traveling to second bandpass filter 209 to pass through such that emission line of interest 20 is blocked and at least a portion of light 12 traveling to second bandpass filter 209 with a longer or a shorter wavelength than emission line of interest 20 is allowed to pass through second bandpass filter 209. The choice of second bandpass filter 209 is dependent on the design of first bandpass filter 208 and the elements present in the sample being analyzed. First bandpass filter 208 and second bandpass filter 209 are not required to be at the same angle. Second bandpass filter 209 should block emission line of interest 20 such that it is no longer detected and allow a different band, shown in **FIG. 2** as reference numeral 21, to pass through and be detected. This different band should be chosen such that no emission line from other elements in the sample are analyzed. In some cases, this will be a higher frequency and in other cases it will be a lower frequency. A person of skill will be able to determine a suitable second bandpass filter 209 for each sample to be tested. By choosing the correct second bandpass filter 209, only random noise generated by equipment will be detected. Removing this noise during analysis leaves you with the emission line of interest 20.

[0062] Prior to passing through first bandpass filter 208 or second bandpass filter 209, at least a portion of light may travel through a first optical collimating component 206. First optical collimating component 206 collimates at least a portion of light 12 from glow discharge apparatus 204 to collimated light 13. When a first optical collimating component 206 is provided, first bandpass filter 208 is offset from the direction of travel of collimated light 13 such that an emission line of interest 20 passes through first bandpass filter 208. Second bandpass filter 209 allows at least a portion of collimated light

13 to pass through such that emission line of interest 20 is blocked and at least a portion of collimated light with a longer or a shorter wavelength than emission line of interest 20 is allowed to pass through second bandpass filter 209.

[0063] A lens 222 is provided for reforming at least a portion of light 13 as reformed light 15 after it has passed through first bandpass filter 208 or second bandpass filter 209. Lens 222 may be a plano-convex lens or may include two plano-convex lenses such that light is collimated and then flipped and focused. The reformed light 15 may be analyzed by an analyzing device 24 such as a spectrometer, monochromator, photomultiplier tube, photodiodes or any other analyzing device or other dispersive element known to a person skilled in the art for spectral discrimination. Total light intensity may also be analyzed.

[0064] Referring to **FIG. 9**, a fibre optic cable 26 may be provided for passing reformed light 15 to analyzing device 24 such as a spectrometer or monochromator. Lens 222 reforms the light to correspond to the image of the plasma 11 created by glow discharge apparatus 204. When light is reformed, it may reform the image of plasma 11 created by glow discharge apparatus 204 in a 1:1 ratio or some other ratio as may be determined by someone skilled in the art. This allows fibre optic cable 26 to be placed in a specific location within reformed light 15 to maximize the signal of the desired element and minimize as much as possible of others. The positioning of fibre optic cable will be understood by a person skilled in the art.

[0065] Any use herein of any terms describing an interaction between elements is not meant to limit the interaction to direct interaction between the subject elements and may also include indirect interaction between the elements such as through secondary or intermediary structure unless specifically stated otherwise.

[0066] In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one of the elements.

[0067] It will be apparent that changes may be made to the illustrative embodiments, while falling within the scope of the invention. As such, the scope of the following claims should not be limited by the preferred embodiments set forth in the examples and drawings described above, but should be given the broadest interpretation consistent with the description as a whole.

CLAIMS

What is claimed is:

1. A system for detecting single elemental emission lines in a glow discharge, comprising:

a glow discharge emitting a light, at least a portion of the light traveling to a bandpass filter;

a bandpass filter, the bandpass filter being rotatable between a first angle and a second angle, the first angle being offset from the direction of travel of the at least a portion of the light traveling from the glow discharge such that an emission line of interest passes through the bandpass filter, the second angle blocking the emission line of interest and allowing the at least a portion of the light traveling from the glow discharge having a longer or a shorter wavelength than the emission line of interest to pass through the bandpass filter.

2. The system of claim 1 further comprising a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the bandpass filter such that light is collimated prior to traveling to the bandpass filter.

3. The system of claim 1 further comprising a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the bandpass filter.

4. The system of claim 1 further comprising a dispersive element for spectral discrimination.

5. The system of claim 1 further comprising a fibre optic cable for passing the light to an analyzing device.

6. The system of claim 1 wherein the bandpass filter is rotated between the first angle and the second angle manually.

7. The system of claim 1 wherein rotation of the bandpass filter between the first angle and the second angle is automated.

8. The system of claim 6 wherein the bandpass filter is positioned on a rotating stage.

9. A method for detecting single elemental emission lines in a glow discharge, comprising the steps of:

activating a glow discharge to create a light;

providing a bandpass filter being rotatable between a first angle and a second angle, the first angle being offset from a direction of travel of at least a portion of the light traveling from the glow discharge such that an emission line of interest passes through the bandpass filter, the second angle blocking the emission line of interest and allowing at least a portion of the light traveling from the glow discharge having a longer or a shorter wavelength than the emission line of interest to pass through the bandpass filter;

passing at least a portion of the light through the bandpass filter positioned at the first angle and recording at least one first data point;

passing at least a portion of the light through the bandpass filter positioned at the second angle and recording at least one second data point;

analyzing the at least one first data point and the at least one second data point.

10. The method of claim 9 further comprising the step of collimating at least a portion of the light from the glow discharge in a first collimating component to create a collimated light prior to the light passing through the bandpass filter.

11. The method of claim 9 further comprising the step of recollimating the light passing through the bandpass filter.

12. The method of claim 11 further comprising the step of completing a spectral discrimination analysis.

13. The method of claim 11 further comprising the step of providing a fibre optic cable for passing the light to an analyzing device.

14. The method of claim 9 wherein the bandpass filter is rotated between the first angle and the second angle manually.

15. The method of claim 9 wherein rotation of the bandpass filter between the first angle and the second angle is automated.

16. The method of claim 15 wherein the bandpass filter is positioned on a rotating stage.

17. A system for detecting single elemental emission lines in a glow discharge, comprising:

a glow discharge emitting a light, at least a portion of the light traveling to a first bandpass filter and a second bandpass filter;

a first bandpass filter being positioned at a first angle, the first angle being offset from the direction of travel of the at least a portion of the light traveling from the glow discharge such that an emission line of interest passes through the first bandpass filter;

a second bandpass filter being positioned at a second angle, the second angle being offset from the direction of travel of the at least a portion of the light traveling from the glow discharge such that the at least a portion of the light traveling from the glow discharge having a longer or a shorter wavelength than the emission line of interest passes through the second bandpass filter and the emission line of interest is blocked.

18. The system of claim 17 further comprising a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the first bandpass filter such that light is collimated prior to traveling to the first bandpass filter.

19. The system of claim 17 further comprising a second optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the second bandpass filter such that light is collimated prior to traveling to the second bandpass filter.

20. The system of claim 17 further comprising a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the first bandpass filter and a second lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the second bandpass filter.

21. The system of claim 20 further comprising a dispersive element for spectral discrimination.

22. The system of claim 20 further comprising a fibre optic cable for passing the light to an analyzing device.

23. A system for detecting single elemental emission lines in a glow discharge, comprising:

a glow discharge emitting a light, at least a portion of the light traveling to a first bandpass filter or a second bandpass filter;

the first bandpass filter allowing at least a portion of the light traveling from the glow discharge to pass through the first bandpass filter such that an emission line of interest passes through the first bandpass filter;

the second bandpass filter interchangeable with the first bandpass filter, the second bandpass filter traveling from the glow discharge to pass through the second bandpass filter such that the emission line of interest is blocked and at least a portion of the light being collimated by the first optical collimating component having a longer or a shorter wavelength than the emission line of interest to pass through the second bandpass filter.

24. The system of claim 23 further comprising a first optical collimating component for collimating at least a portion of the light emitted from the glow discharge positioned between the glow discharge and the first bandpass filter and the second bandpass filter such that light is collimated prior to traveling to the first bandpass filter and the second bandpass filter.

25. The system of claim 23 further comprising a lens for reforming the at least a portion of the light after the at least a portion of the light has passed through the first bandpass filter or the second bandpass filter.

26. The system of claim 25 further comprising a dispersive element for spectral discrimination.

27. The system of claim 25 further comprising a fibre optic cable for passing the light to an analyzing device.

28. The system of claim 23 wherein the first bandpass filter and the second bandpass filter are switched automatically.

29. The system of claim 23 wherein at least one of the first bandpass filter and the second bandpass filter is rotatable to an angle different from the other of the first bandpass filter or the second bandpass filter.

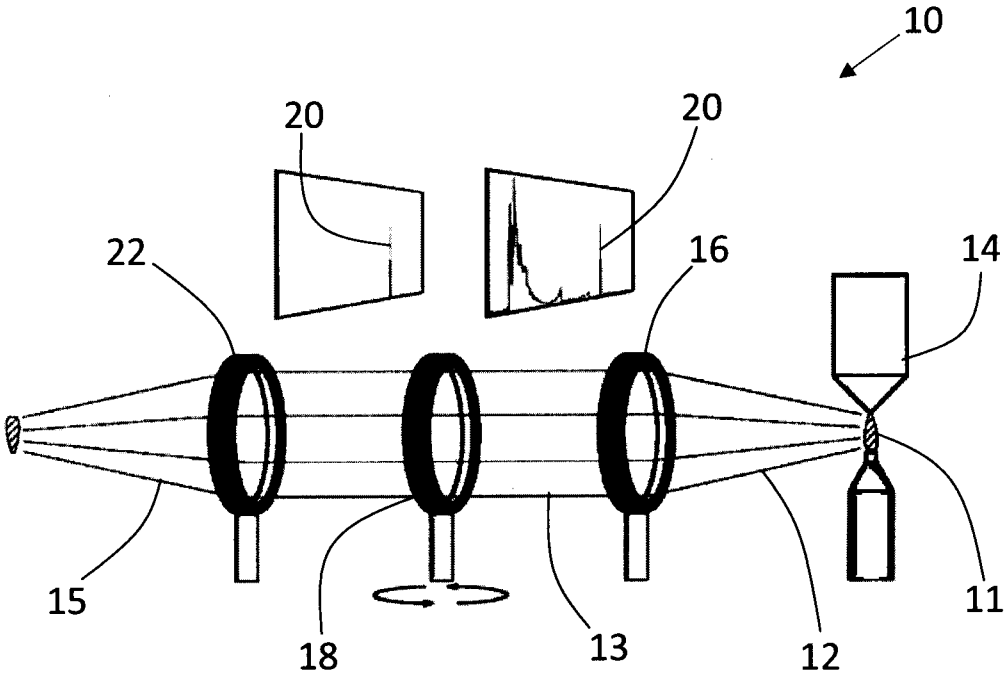


FIG. 1

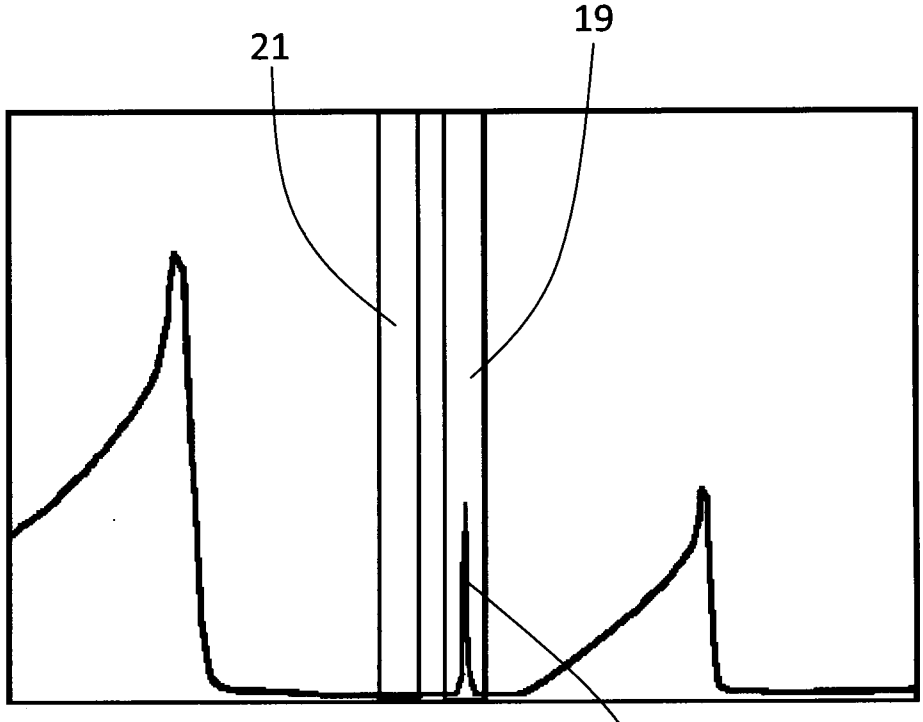


FIG. 2

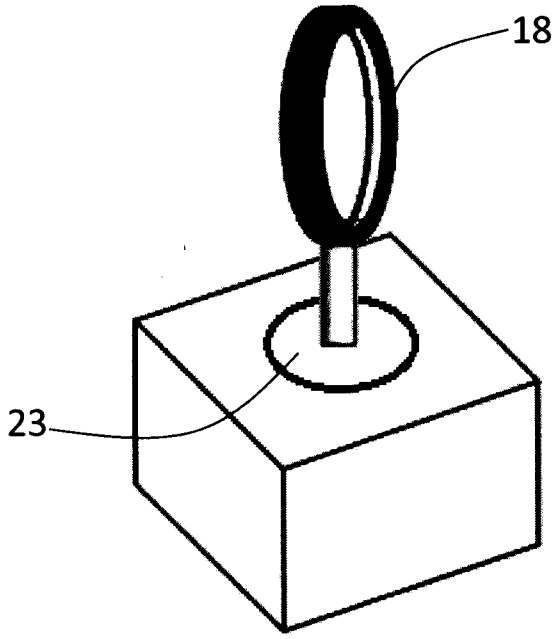


FIG. 3

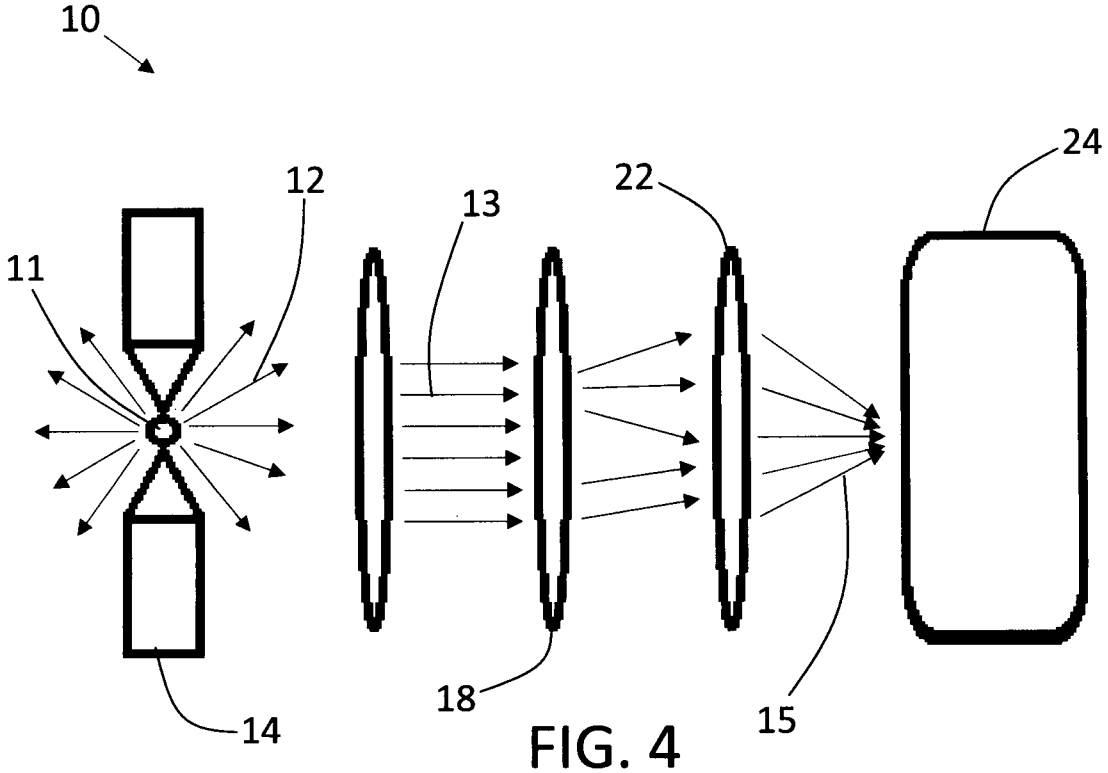


FIG. 4

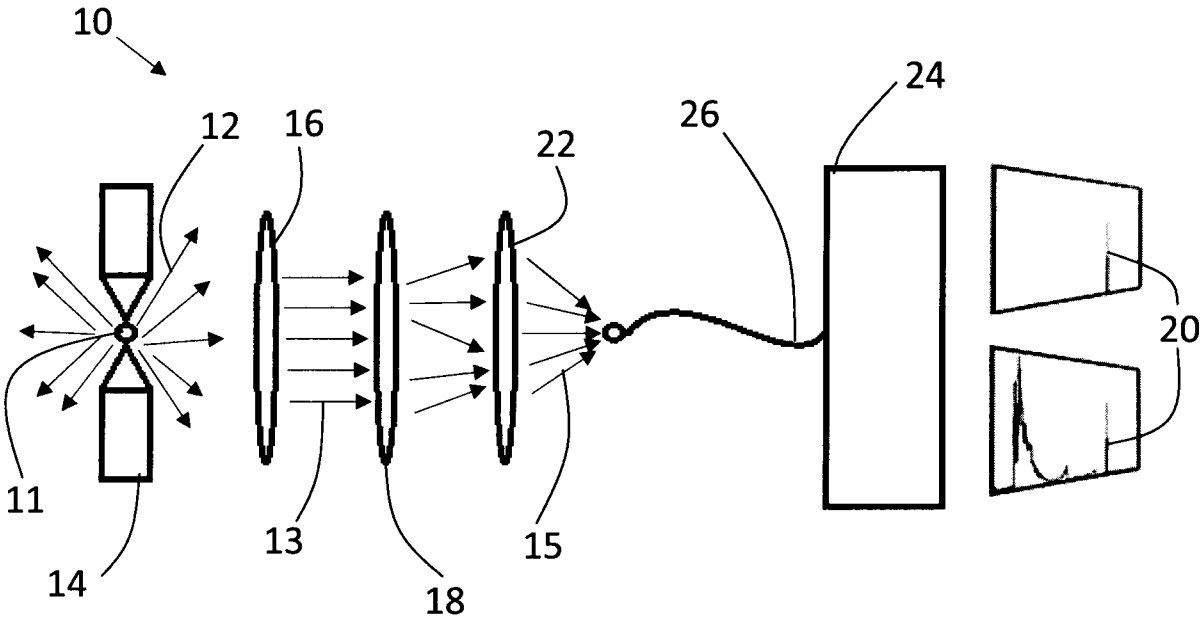

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FIG. 5

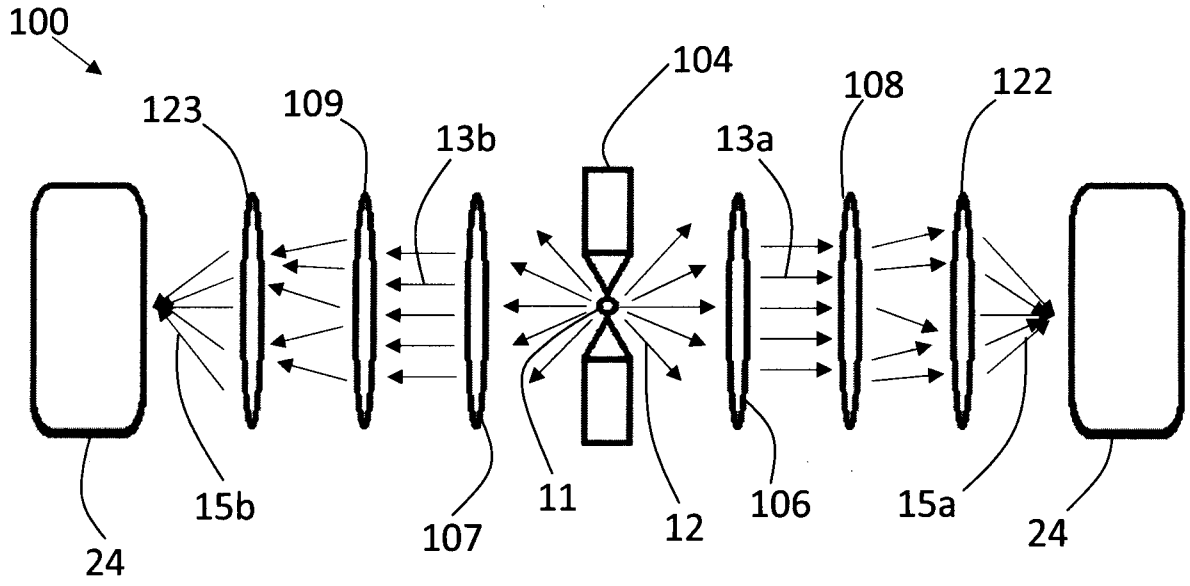
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FIG. 6

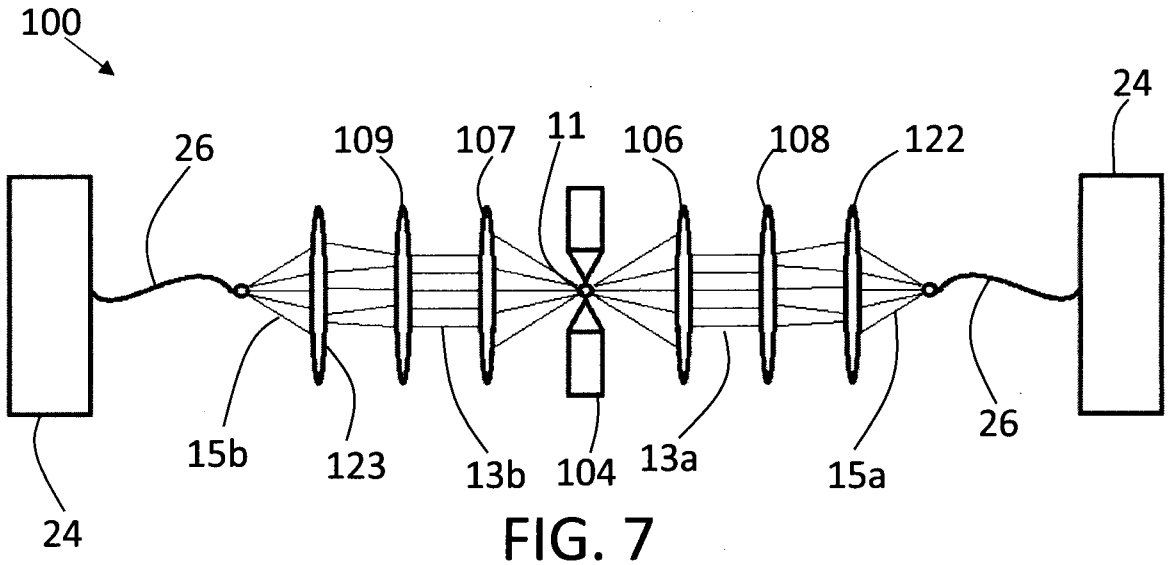
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FIG. 7

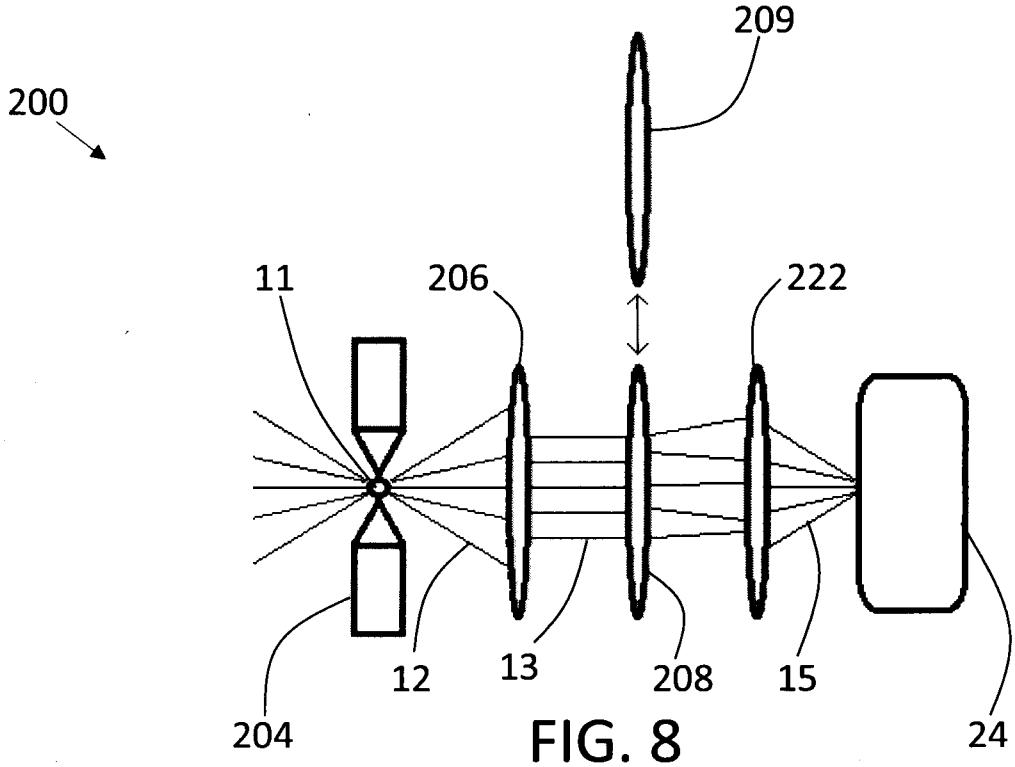
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FIG. 8

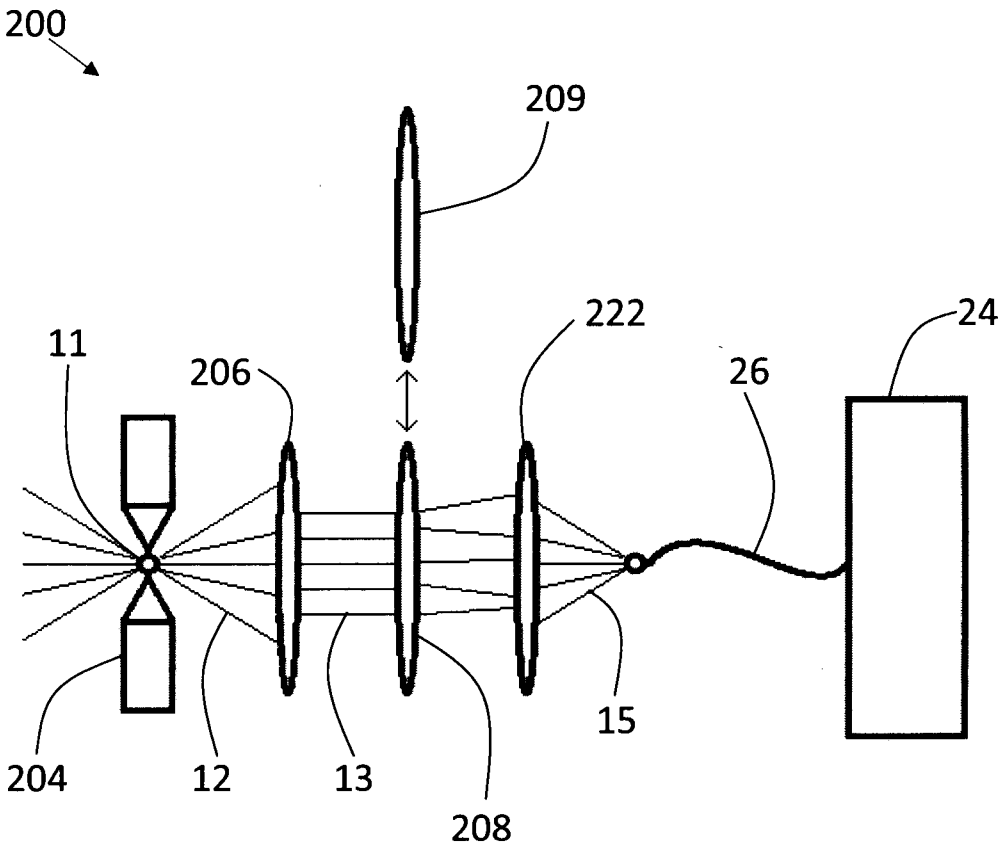
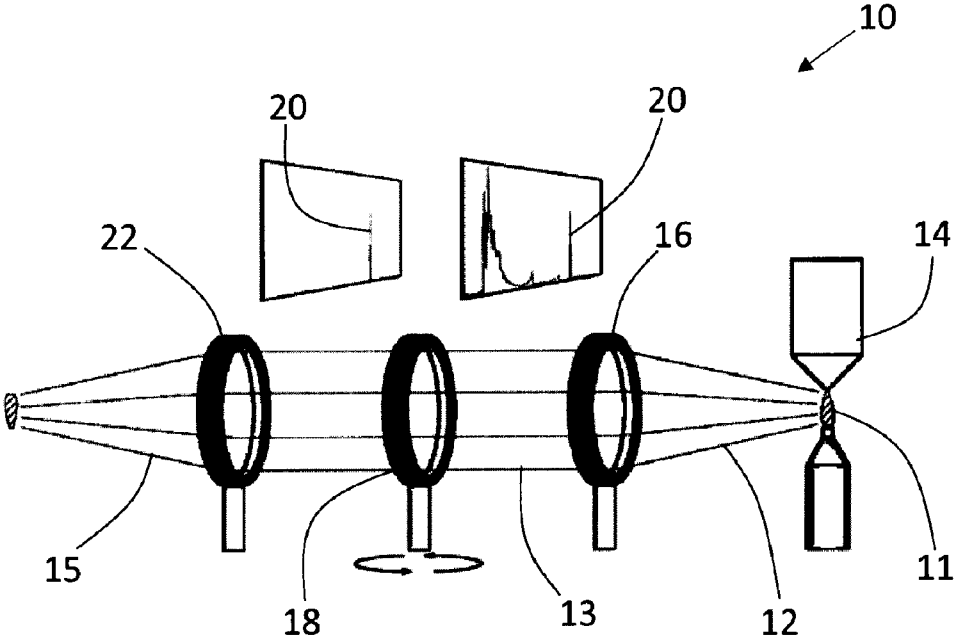


FIG. 9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