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(73) Titulaire(s):
UNIVERSITÉ DE MONS – 1700 Mons (Belgium)

(72) Inventeur(s):
QUENON Alexandre – Belgium, DEMARBAIX Anthonin – Belgium, DEMARET Benjamin – Belgium

(74) Mandataire(s):
ARC-IP sprl - Guy Farmer – 1435 MONT SAINT GUIBERT (Belgium)

(54) ANALYZING APPARATUS.

(57) The invention relates to an apparatus configured to detect and measure in real time an electrical response from an electrical component exposed to ionizing radiation.

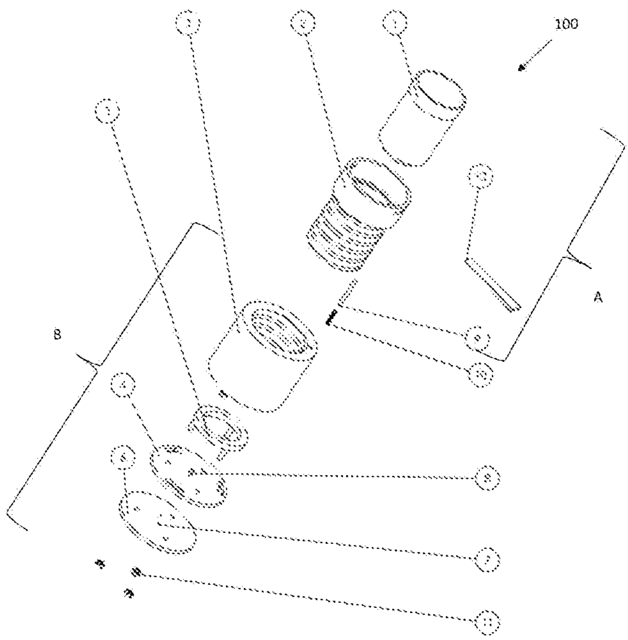

Fig 1

ANALYZING APPARATUS

[0001] The present invention relates to an apparatus configured to detect and measure in real time an electrical response from an electrical component exposed to ionizing radiation.

[0002] For both safety for humans and for the environment, nuclear technologies require remote monitoring with energy-independent systems. Remote monitoring is already proposed by the industry in which the energy autonomy can be achieved by means of energy harvesting. However, the energy sources that are usually harvested, such as light, heat, mechanical vibrations or radio-frequency waves, are not always available or reliable in nuclear applications. Therefore, no universal energy harvesting solution can be built to operate in nuclear environments. Yet, the sole energy source that is permanently present in the closed environment comes from the application itself: ionizing radiation emitted by a nuclear material. Harvesting energy produced by electrical component exposed to ionizing radiation could be of interest if such an energy is sufficient.

[0003] In order to determine if such an energy can be harvested, analysis of electrical components and their electrical response(s) when only exposed to ionizing radiation is needed.

[0004] Previous analysing systems measure electrical response(s) from an electrical component after being exposed to an ionizing radiation. Whilst this allows assessment of possible changes in the electrical response following exposure to ionizing radiation, for example change in the DC current response, this does not allow monitoring in real time the response from the electrical component during exposition to radiation or assessment as to whether harvesting of the electrical response from an electrical component when exposed to ionizing radiation for alternate applications is possible.

[0005] There is thus a need for an instrumentation developed to measure in real time at a chosen distance the influence of ionizing radiation from a source on an electrical component such as a diode and which ensures repeatability and accuracy of measurements.

[0006] In accordance with one of its aspects, the present invention provides an apparatus according to claim 1 configured to detect and measure in real time an electrical response from an electrical component exposed to ionizing radiation. Other aspects are defined in other independent claims. The dependent claims define preferred or alternative embodiments.

[0007] The enclosure of the apparatus prevents, in a shielding configuration, penetration of external radiation, for example visible light, into the enclosure. By “visible light”, it is understood radiation having a wavelength in the range 400-800nm. Preventing penetration of external radiation into the enclosure avoids adding parasitic noise to the measurement and analysis of the electrical component, particularly when exposed to ionizing radiation. Preferably, the enclosure prevents, in a shielding configuration, penetration of at least 80% of external radiation, preferably at least 90%, more preferably at least 95% and even more preferably at least 98%. In a preferred embodiment, the enclosure prevents, in a shielding configuration, penetration of at least 99% of external radiation, notably visible light.

[0008] In a preferred embodiment, the enclosure is provided by the exposed external surfaces of the electrical component support (the surfaces susceptible to be exposed to radiation originating from a radiation source outside the apparatus), the adjustment mechanism and the ionizing radiation source support, when assembled together.

[0009] The shielding configuration is the configuration in which the ionizing radiation emitting source support, optionally the ionizing radiation emitting source, and the electrical component support are assembled within the enclosure of the apparatus and in which the lowest amount of external radiation can penetrate from the outside to the inside the enclosure. Exposure(s) of the electrical component by ionizing radiation and measurement of dark current are carried out in the shielding configuration.

[0010] In order to prevent penetration of exterior radiation, i.e. radiation originating from a radiation source outside the apparatus, the enclosure may comprise, on its external surfaces, a radiation-reflecting and/or a radiation-absorbing material. A radiation-reflecting and/or a radiation-absorbing material may also be provided on the internal surfaces of the apparatus, in combination or not with a radiation-reflecting and/or a radiation-absorbing material on the external surfaces. This may provide a further barrier preventing exterior radiation that could go through the thickness of the enclosure to penetrate inside the enclosure.
The radiation-reflecting and/or a radiation-absorbing material may be in the form of radiation-reflecting and/or radiation-absorbing particles embedded in the material forming the enclosure or in the form of a radiation-reflecting and/or a radiation-absorbing coating, notably a coating covering at least 75%, at least 80%, at least 95%, at least 99% of the whole internal and/or external surface of the enclosure. The reflective material may reflect at least 85%, at least 95%, at least 99% of the external radiation, notably the visible light. The absorbing material may absorb at least 85%, at least 95%, at least 99% of the external radiation, notably the visible light.
The enclosure preferably comprises a black coating, for example a black vinyl, on its external surface and/or on its internal surface. In one embodiment, a reflecting material is provided, notably in the form of a coating, on the internal surface of the enclosure and an absorbing material is provided, for example in the form of a coating, on the external surface of the enclosure.

[0011] In a preferred embodiment, the enclosure and/or the electrical component support are electrically insulated and/or insulated from external radiation, notably insulated from external visible light. The enclosure and/or the electrical component support may be made of an insulating material and/or may comprise an insulating coating. The enclosure and/or the electrical component support may comprise a plastics material, for example a plastic selected from acrylonitrile butadiene styrene (ABS) or Poly(methyl methacrylate) (PMMA), polylactic acid (PLA), chlorinated polyethylene (CPE), nylon. These materials are suitable to be used for 3D-printing. An insulated enclosure and/or insulated electrical component support decreases or avoids electrical noise in the electrical response during analysis.

[0012] For analyzing the response from the electrical component when exposed to an ionizing radiation, the ionizing radiation emitting source may be selected from the group consisting of radiation of : alpha, beta (electron or positron), gamma, neutron and proton. The energy of the ionizing radiation may depend on the selected ionizing radiation, the distance between the ionizing radiation emitting source, the electrical component and/or the exposure time of the electrical component by the ionizing radiation. The skilled addressee will be able to adapt the required energy for each set of measurement(s).

[0013] In a preferred embodiment, the ionizing radiation is polarized; this may be used to provide a better electrical response from the exposed electrical component. A non-polarized ionizing radiation may also be used.

[0014] Preferably, the ionizing radiation is collimated. In a preferred embodiment, the ionizing radiation is polarized and collimated. This provides a focused beam, increasing the concentration of radiation directed towards the electrical component.

[0015] The ionizing radiation emitting source and/or the ionizing radiation emitting source support is preferably secured to a portion of the enclosure of the apparatus by removable attachment. This allows the ionizing radiation emitting source to be changed, for example, from a source of alpha radiation to a source of proton radiation, for analyzing the same electrical component, without changing the complete apparatus. The apparatus may comprise, notably at one of the ends of the enclosure, radiation source connecting means configured to be connected to corresponding connecting means provided on the radiation emitting source. The ionizing radiation emitting source and/or the ionizing radiation emitting source support may be secured to the apparatus by a screwing system, a bayonet system, or a clipping system.

[0016] Alternatively, the ionizing radiation emitting source and/or the ionizing radiation emitting source support may be removably secured to a portion of the enclosure by an attachment system which, in an active position, prevents displacement of the radiation emitting source with respect of the enclosure of the apparatus, for example, by preventing the emitting source or emitting source support from being moved with respect to the portion of the enclosure to which the source or source support is attached.

[0017] In a preferred embodiment, the ionizing radiation emitting source support is fixed with respect to the enclosure of the apparatus and the electrical component support is moveable along the longitudinal axis with respect to the enclosure. Alternatively the ionizing radiation emitting source support is moveable along the longitudinal axis with respect to the enclosure of the apparatus and the electrical component support is fixed with respect to the enclosure. This configuration allows the distance between the emitting source and the electrical component to be varied. Changing the distance is of interest as it allows analysis of the influence of the distance to the electrical response from an electrical component when exposed or it may be required because of the different desired path lengths for different ionizing radiation. The distance between the electrical component and the ionizing radiation emitting source may vary according to the needs of the measurement(s). It may be less than 0.5mm, for example the electrical component may be in direct contact with the radiation source, maximizing the electrical response of the exposed electrical component.

[0018] The mechanism for adjusting the distance between the ionizing radiation emitting source support and the electrical component support may be configured to allow sliding only in a plurality of stepped adjustment positions in the axial direction, for example with a pitch in the range between 5 mm and 15mm. The adjustment may be carried out by i) sliding one of the electrical component support and the ionizing radiation emitting source support with respect of the enclosure of the apparatus, along the longitudinal axis or ii) by means of a rack and pinion transmission between the ionizing radiation emitting source support and the electrical component support.
Particularly when the adjustment is provided by sliding one of the electrical component support and the ionizing radiation emitting source support with respect of the enclosure of the apparatus, along the longitudinal axis, the adjustment mechanism may be configured so that one of the electrical component support and the ionizing radiation emitting source support can slide relative to the enclosure in a first relative angular position, and one of the electrical component support and the ionizing radiation emitting source support are suitable for pivoting towards a second relative angular position in which they are locked in axial direction with respect to the enclosure, preferably in only a plurality of stepped positions in the axial direction, for example with a pitch in the range between 5 mm and 15mm. In another embodiment, the adjustment means may comprise screwing means. In a preferred embodiment, the adjustment mechanism is configured to allow sliding of the ionizing radiation emitting source support with respect to the enclosure. In this configuration, the position of the electrical component support is fixed with respect of the enclosure.
Particularly when the adjustment is provided by means of a rack and pinion transmission

between the ionizing radiation emitting source support and the electrical component support, the rack may be positioned on the electrical component support (female part) and a pinion assembled on a micromotor on the radiation emitting source support (male part) may allow the translation, notably in a plurality of stepped positions in the axial direction, for example with a pitch in the range between 5 mm and 15mm. In this configuration, the adjustment may be operated with an electrical control unit.

[0019] In a preferred embodiment, the distance between the electrical component secured on the electrical component support and the ionizing radiation emitting source secured to the ionizing radiation emitting source support can be adjusted in the shielding configuration. This avoids dissembling the apparatus for adjusting the distance.

[0020] For facilitating transport and use of the apparatus on site, the apparatus may have an elongated shape, preferably having a substantially cylindrical shape, notably a substantially cylindrical shape having :
- a length of at least 10cm, at least 20cm and/or less than 30cm, preferably less than 20cm; and/or
- a diameter of at least 5cm, at least 10cm and/or less than 20cm or less than 15cm.

[0021] The analyzing system, connected to the electrical component via electrical connector(s), may measure electrical response from the electrical component selected from: voltage, current, notably DC current, magnetic field, electric charge, impedance and combinations thereof. Preferably the analyzing system comprises an electrometer. The electrometer may be configured to detect current of less than 100pA, less than 10pA, less than 1pA and/or at least 100fA, at least 10fA or at least 1fA. The analyzing system may measure electrical response before exposure of the electrical component, for example for assessing the behavior of the electrical component without excitement by radiation exposure, during exposure or after exposure, for example for assessing possible electrical response delay following exposure by ionizing radiation. The connection between analyzing system and the electrical component via the electrical connector(s) may be via optical fiber(s), which provide faster response and detection than electrical wire(s).

[0022] For maximizing the electrical response of the electrical component, it is preferable that the electrical component support surface (and the electrical component thereon during exposure) is perpendicular to the longitudinal axis of the apparatus. The longitudinal axis is defined as the axis along which ionizing radiation would travel if it were a laser beam. In one embodiment, the electrical support component is tiltable with respect of the longitudinal axis. This may help to evaluate the electrical response of the electrical component with respect to the ionizing radiation.

[0023] According to another embodiment, the invention provides a method of measuring at least an electrical response of an electrical component exposed to an ionizing radiation, notably by using the above-described apparatus.

[0024] During exposure of the electrical component to the ionizing radiation, an external bias voltage may be applied on the electrical component. Applying a bias voltage may increase the current generated in the electrical component, particularly when the electrical component is a semi-conductor, and may decrease the “recovery time”, i.e. the time after which the electrical response from the electrical component after exposure is substantially equal to the electrical response from the electrical component before exposure. It may also be possible to compare the electrical behavior of the electrical component by applying an external bias voltage during a first exposure and by not applying an external bias voltage during a second exposure, and notably in which the other parameters (exposure time, distance, type of ionizing radiation, etc.) are the same or substantially the same.

[0025] The electrical component adapted to be exposed to ionizing radiation may be a diode, preferably a photodiode. Other examples of adapted electrical components are: integrated circuits (chips), resistors, capacitors, inductors, and semiconductor devices.

[0026] Prior to exposing the electrical component to the ionizing radiation, the analyzing system may measure, in the shielding configuration, the dark current of the electrical component. "Dark current" is understood as the electrical response (voltage, current, or other electrical response as listed above) without being exposed to any radiation (external and from the ionizing radiation emitting source), including visible light.

[0027] An embodiment of the invention will be described in more detail, by way of example only, with reference to the attached drawings of which:
Fig. 1 is a schematic exploded-view of an apparatus according to the invention;
Fig. 2 is a schematic mounted-view of the apparatus of Fig.1;
Fig. 3 is a measurement chart.

[0028] The apparatus 100 comprises a first sub-assembly A comprising a radiation source 1 and a second sub-assembly B in which an electrical component can be provided. A male threaded connected sleeve 2 is assembled on the radiation source 1 of beta radiation. The radiation source is connected by means of a sliding fit to radiation source holder (not shown). The source holder will serve as a reference surface to ensure the repeatability of the measurement of the distance between the source and the electrical component, for example by using a vernier scale. The sleeve 2 is secured to the radiation source with a locking device 12 which hold the sub-assembly A together. A female threaded sleeve 3 is secured to the sub-assembly A and allows axial movement between the male sleeve 2 and the female sleeve 3. The adjustment mechanism is provided by screwing the female sleeve 3 and the male sleeve 2 together. The displacement distance between the radiation source and the diode 8 is measured using a graduated gauge 9 which slides into the female threaded sleeve 3 and is positioned in the male threaded sleeve 2 with the help of a spring 10. At the end of the male threaded sleeve 3, three locating pins (only one pin is visible in Fig.1) are positioned around the periphery of the sleeve, each spaced from an angle of about 120° from the center of the end of the sleeve 3.

[0029] A diode 8 is secured to the plate 4 by passing its leg(s) through openings on the first plate 4 and second plate 6. Once the legs have crossed the plates, they are bent back on themselves. A ring 5, having an external diameter smaller than the internal diameter of the sleeve 3 and comprising three threaded extrusions is attached over the plate 4 by passing the three threaded extrusions through openings of both plates 4,6. Gold nails 11 prevent displacement of the three threaded extrusions with respect of the plates 4,6. Connectors 7 are used to ensure contact with the diode's legs. Bolts are further used to ensure contact between the gold nails and the legs of the diode, thereby providing the sub-assembly B.
The three locating pins of the sub-assembly A allows connecting it to corresponding holes provided on the plate 4 the sub-assembly B by a ¼ turn rotation, ensuring the alignment of the diode and the distance between the source 1 and the plate 4.

[0030] Elements 2, 3, and 5 are made of acrylonitrile butadiene styrene (ABS) and the elements 12, 4 and 6 are made of Poly(methyl methacrylate) (PMMA) coated with black vinyl to prevent exterior radiation to penetrate within the apparatus once the sub-assemblies A and B are secured.

[0031] Description of an example test

[0032] The measurement process used is the following:
1) calibrating of the electrometer, calibrating comprising warming-up;

2) running multiple or continuous acquisitions to measure the diode's dark current in the absence of ionizing radiation;
3) placing the beta radiation source;
4) running multiple or continuous acquisitions to measure the effect of beta radiation on the diode's dark current.

[0033] The electrical component is a BPW34 pin photodiode and the beta particles are produced by ^{90}Sr, hence ranging from 0MeV to 2,283MeV. The source activity is around 150MBq, but the counting rate at the output of the collimator is around 5000 counts on a 28mm^2 circular surface. The distance between the photodiode and the source of beta radiation is set at 0mm.

[0034] The average increase in DC current is about 12 pA. An increase in the peak-to-peak amplitude of about 800 fA is also observed, which is due to bursts of currents of approximately 1 pA peak-to-peak amplitude and a few tens or hundreds of milliseconds of duration. These bursts are not observed when the radiation source is removed. The results shown have been obtained by averaging five runs of 1 second, for each condition (normal operation and beta radiation exposure).

[0035] Figure 3 illustrates the evolution of diode's dark current over time in normal and beta radiation operation. All signals' 50 Hz components have been filtered by a FTT method and all DC offsets are cancelled for easier comparison of AC behavior.

CLAIMS

1. Apparatus configured to detect and measure in real time an electrical response from an electrical component exposed to ionizing radiation, the apparatus comprising:
- an enclosure preventing, when in a shielding configuration, penetration of exterior radiation, notably penetration of visible light, into the inside of the enclosure;
- an electrical component support provided at one end of the apparatus and adapted to receive and removably secure, during measurement, an electrical component;
- an ionizing radiation emitting source support at an opposed end of the apparatus adapted to receive and removably secure during measurement an ionizing radiation emitting source configured to emit a first ionizing radiation exposure towards the electrical component along a longitudinal axis, and
- a mechanism configured to adjust the distance between the ionizing radiation emitting source support and the electrical component support along the longitudinal axis; and
- electrical connector(s) configured to electrically connect the electrical component to an analyzing system, notably an analyzing system configured to measure the electrical response from the electrical component,

wherein the electrical component support and the ionizing radiation emitting source support are configured so that, in the shielding configuration, an electrical component secured to the electrical component support and an ionizing radiation emitting source secured to the ionizing radiation emitting source support are positioned inside the enclosure.

2. Apparatus according to claim 1, wherein the apparatus further comprises:
- an ionizing radiation emitting source, secured to the ionizing radiation emitting source support and configured to emit a first ionizing radiation exposure towards the electrical component along a longitudinal axis; and/or
- the analyzing system connected to the apparatus via the electrical connector(s).

3. Apparatus according to any preceding claim, wherein the analyzing system comprises an electrometer, notably an electrometer configured to detect current of at least 1fA and/or less than 100pA.

4. Apparatus according to any preceding claim, wherein the adjustment mechanism allows sliding of
- the ionizing radiation emitting source support with respect to the enclosure and the electrical component support is fixed with respect to the enclosure; or
- the electrical component support with respect to the enclosure and the ionizing radiation emitting source support is fixed with respect to the enclosure .

5. Apparatus according to any preceding claim, wherein the electrical component support is orientated perpendicular to the longitudinal axis of the apparatus.

6. Apparatus according to any of claims 2-5, wherein the ionizing radiation emitting source is configured to emit radiation selected from the group consisting of radiation of: alpha, beta (electron or positron), gamma, neutron and proton.

7. Apparatus according to any preceding claim, wherein the apparatus has a substantially cylindrical shape, notably a substantially cylindrical shape having length of less than 30cm, preferably less than 20cm and/or is substantially made of electrically insulating material, for example plastics.

8. Apparatus according to any preceding claim, wherein the adjustment mechanism is configured to allow sliding only in a plurality of stepped adjustment positions in the longitudinal axis with a pitch of the steps in the range between 5 mm and 15mm.

9. Apparatus according to any preceding claim, wherein the enclosure is configured to prevent penetration of at least 90% of external radiation, notably visible light, inside the enclosure, preferably at least 95%, more preferably at least 98%, and even more preferably at least 99%. LU501011

10. Method of detecting and measuring electrical response(s) from an electrical component exposed to ionizing radiation, comprising:
- providing an apparatus, notably the apparatus in accordance with any of claims 1 to 9, comprising i) an enclosure preventing, when in a shielding configuration, penetration of exterior radiation, notably visible light, into the inside the enclosure; ii) an electrical component support provided at one end of the apparatus and adapted to receive and removably secure, during measurement, an electrical component; iii) an ionizing radiation emitting source support at an opposed end of the apparatus adapted to receive and removably secure, during measurement, an ionizing radiation emitting source configured to emit a first ionizing radiation exposure towards the electrical component along a longitudinal axis; iv) a mechanism configured to adjust the distance between the ionizing radiation emitting source support and the electrical component support along the longitudinal axis; v) electrical connector(s) configured to electrically connect the electrical component to an analyzing system, notably an analyzing system configured to measure the electrical response from the electrical component, wherein the electrical component support and the ionizing radiation emitting source support are configured so that, in the shielding configuration, an electrical component secured to the electrical component support and an ionizing radiation emitting source secured to the ionizing radiation emitting source support are positioned inside the enclosure;
- providing an electrical component at the electrical component support of the apparatus;
- providing, at the ionizing radiation emitting source support, an ionizing radiation emitting source configured to emit a first ionizing radiation exposure towards the electrical component along a longitudinal axis;
- configuring the enclosure in a shielding configuration so that the electrical component and the ionizing radiation emitting source are positioned inside the enclosure;
- exposing the electrical component to a first ionizing radiation exposure, and
- measuring an electrical response from the electrical component by the analyzing system during the exposure, notably an electrometer.

11. The method of claim 10, wherein no external bias voltage is applied to the electrical component during the first ionizing radiation exposure.

12. The method of claim 10, wherein an external bias voltage is applied to the electrical component during the first ionizing radiation exposure.

13. The method of any of claims 10-12, wherein the electrical component is selected from the group consisting of: diodes, preferably photodiodes, integrated circuits (chips), resistors, capacitors, inductors, and semiconductor devices.

14. The method of any of claims 10-13, wherein, between shielding the electrical component from external radiation and exposing the electrical component to a first ionizing radiation exposure, the method further comprises measuring the dark current of the electrical component.

1. Appareil configuré pour détecter et mesurer en temps réel une réponse électrique d'un composant électrique exposé à un rayonnement ionisant, l'appareil comprenant :
- une enceinte empêchant, lorsqu'elle est en configuration de blindage, la pénétration de rayonnement extérieur, notamment la pénétration de la lumière visible, à l'intérieur de l'enceinte ;
- un support de composant électrique prévu à une extrémité de l'appareil et adapté pour recevoir et fixer de façon amovible, lors de la mesure, un composant électrique ;
- un support de source émettrice de rayonnement ionisant à une extrémité opposée de l'appareil adapté pour recevoir et fixer de façon amovible lors de la mesure une source émettrice de rayonnement ionisant configurée pour émettre une première exposition de rayonnement ionisant en direction du composant électrique le long d'un axe longitudinal ; et
- un mécanisme configuré pour régler la distance entre le support de source émettrice de rayonnement ionisant et le support de composants électriques le long de l'axe longitudinal ; et
- des connecteur(s) électrique(s) configuré(s) pour connecter électriquement le composant électrique à un système d'analyse, notamment un système d'analyse configuré pour mesurer la réponse électrique du composant électrique ;
dans lequel le support de composant électrique et le support de source émettrice de rayonnement ionisant sont configurés de sorte que, dans la configuration de blindage, un composant électrique fixé au support de composant électrique et une source émettrice de rayonnement ionisant fixée au support de source émettrice de rayonnement ionisant sont positionnés à l'intérieur de l'enceinte.

2. Appareil selon la revendication 1, dans lequel l'appareil comprend en outre :
- une source émettrice de rayonnement ionisant, fixée au support de source émettrice de rayonnement ionisant et configurée pour émettre une première exposition de rayonnement ionisant en direction du composant électrique le long d'un axe longitudinal ; et/ou
- le système d'analyse connecté à l'appareil via le(s) connecteur(s) électrique(s).

3. Appareil selon l'une quelconque des revendications précédentes, dans lequel le système d'analyse comprend un électromètre, notamment un électromètre configuré pour détecter un courant d'au moins 1fA et/ou inférieur à 100pA.

4. Appareil selon l'une quelconque des revendications précédentes, dans lequel le mécanisme de réglage permet le coulissement du
   - support de la source émettrice de rayonnement ionisant par rapport à l'enceinte et le support de composant électrique est fixe par rapport à l'enceinte ; ou
   - support de composant électrique par rapport à l'enceinte et le support de source émettrice de rayonnement ionisant est fixe par rapport à l'enceinte.

5. Appareil selon l'une quelconque des revendications précédentes, dans lequel le support de composant électrique est orienté perpendiculairement à l'axe longitudinal de l'appareil.

6. Appareil selon l'une quelconque des revendications 2 à 5, dans lequel la source d'émission de rayonnement ionisant est configurée pour émettre un rayonnement sélectionné dans le groupe consistant en un rayonnement parmi : alpha, bêta (électron ou positron), gamma, neutron et proton.

7. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'appareil a une forme substantiellement cylindrique, notamment une forme substantiellement cylindrique ayant une longueur inférieure à 30 cm, de préférence inférieure à 20 cm et/ou est substantiellement constitué d'un matériau électriquement isolant, par exemple du plastique.

8. Appareil selon l'une quelconque des revendications précédentes, dans lequel le mécanisme de réglage est configuré pour permettre le coulissement uniquement dans une pluralité de positions de réglage étagées dans l'axe longitudinal avec un pas de marche compris entre 5 mm et 15 mm.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'enceinte est configurée pour empêcher la pénétration d'au moins 90 % du rayonnement externe, notamment de la lumière visible, à l'intérieur de l'enceinte, de préférence au moins 95 %, plus préférentiellement au moins 98 %, et encore plus préférentiellement à moins 99%.

10. Procédé de détection et de mesure de réponse(s) électrique(s) d'un composant électrique exposé à un rayonnement ionisant, comprenant :
    - fournir un appareil, notamment l'appareil selon l'une quelconque des revendications

1 à 9, comprenant i) une enceinte empêchant, lorsqu'elle est en configuration de blindage, la pénétration de rayonnement extérieur, notamment de la lumière visible, à l'intérieur de l'enceinte ; ii) un support de composant électrique prévu à une extrémité de l'appareil et adapté pour recevoir et fixer de façon amovible, lors de la mesure, un composant électrique ; iii) un support de source émettrice de rayonnement ionisant à une extrémité opposée de l'appareil adapté pour recevoir et fixer de manière amovible, lors de la mesure, une source émettrice de rayonnement ionisant configurée pour émettre une première exposition de rayonnement ionisant vers le composant électrique le long d'un axe longitudinal ; iv) un mécanisme configuré pour régler la distance entre le support de source émettrice de rayonnement ionisant et le support de composant électrique le long de l'axe longitudinal ; v) des connecteur(s) électrique(s) configuré(s) pour connecter électriquement le composant électrique à un système d'analyse, notamment un système d'analyse configuré pour mesurer la réponse électrique du composant électrique, dans lequel le support de composant électrique et le support de source émettrice de rayonnement ionisant sont configurés de sorte que, dans la configuration de blindage, un composant électrique fixé au support de composant électrique et une source émettrice de rayonnement ionisant fixée au support de source émettrice de rayonnement ionisant sont positionnés à l'intérieur de l'enceinte,

- fournir un composant électrique au niveau du support de composant électrique de l'appareil ;
- fournir, au niveau du support de source émettrice de rayonnements ionisants, une source émettrice de rayonnements ionisants configurée pour émettre une première exposition aux rayonnements ionisants vers le composant électrique selon un axe longitudinal ;
- configurer l'enceinte dans une configuration de blindage de sorte que le composant électrique et la source émettrice de rayonnement ionisant soient positionnés à l'intérieur de l'enceinte ;
- exposer le composant électrique à une première exposition de rayonnement ionisant, et
- mesurer une réponse électrique du composant électrique par le système d'analyse lors de l'exposition, notamment un électromètre.

11. Procédé selon la revendication 10, dans lequel aucune tension de polarisation externe n'est appliquée au composant électrique pendant la première exposition de rayonnement ionisant.

12. Procédé selon la revendication 10, dans lequel une tension de polarisation externe est appliquée au composant électrique pendant la première exposition de rayonnement ionisant.

13. Procédé selon l'une quelconque des revendications 10 à 12, dans lequel le composant électrique est sélectionné dans le groupe consistant en : des diodes, de préférence des photodiodes, des circuits intégrés (puces), des résistances, des condensateurs, des inductances et des dispositifs semi-conducteurs.

14. Procédé selon l'une quelconque des revendications 10 à 13, dans lequel, entre le blindage du composant électrique d'un rayonnement externe et l'exposition du composant électrique à une première exposition de rayonnement ionisant, le procédé comprend en outre la mesure du courant d'obscurité du composant électrique.

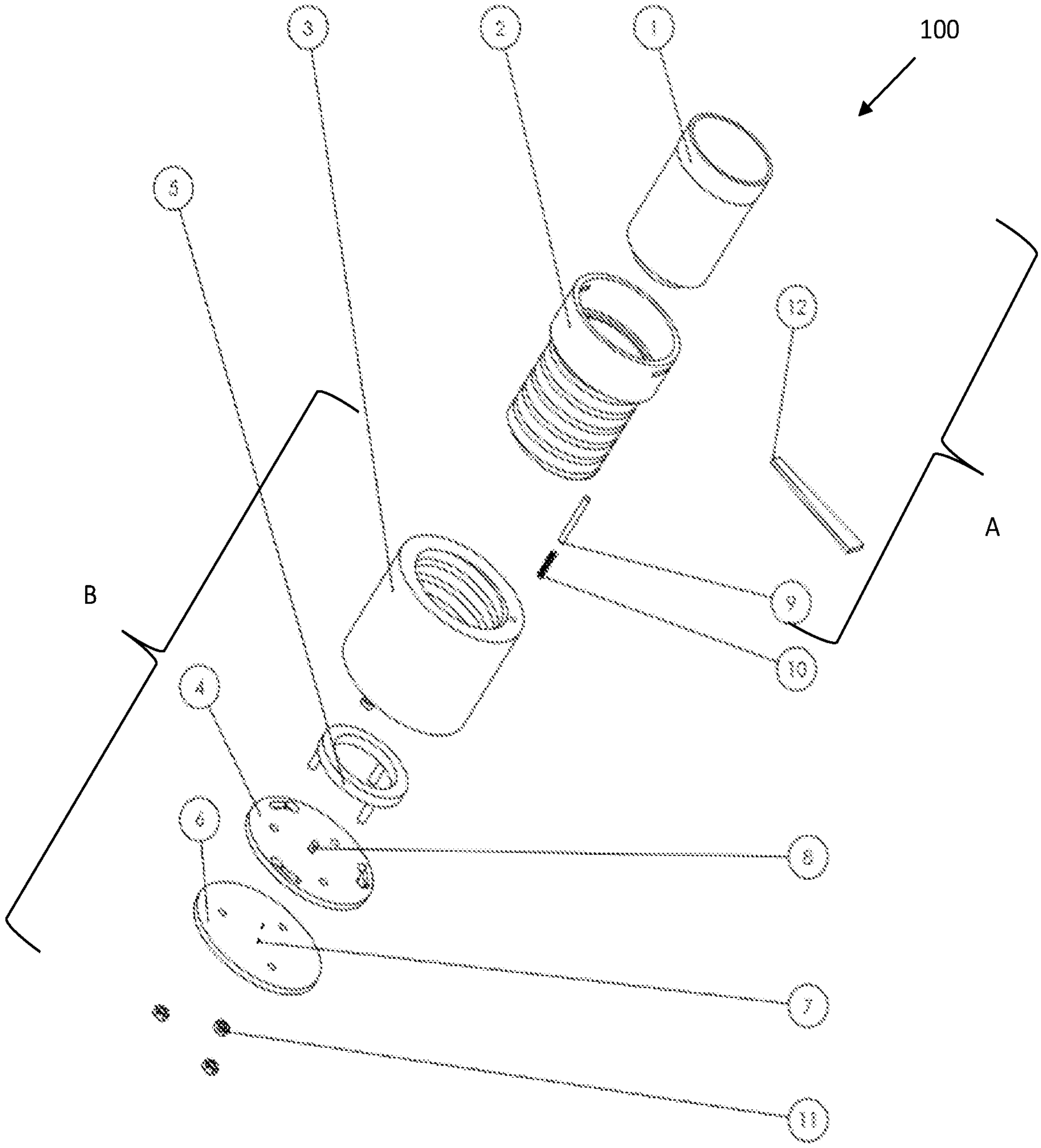

Fig 1

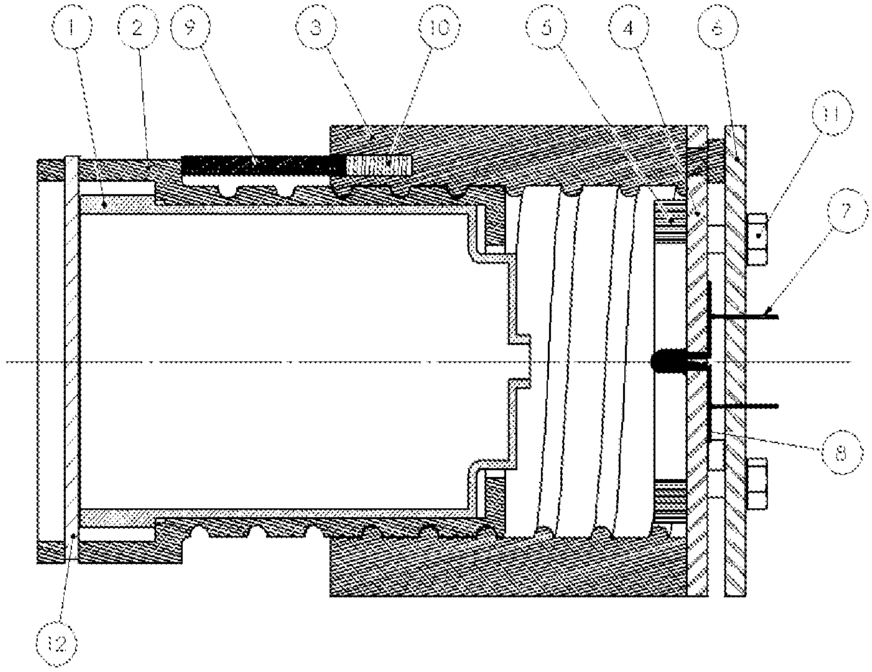
1
2
9
3
10
5
4
6
11
7
8
12

Fig 2

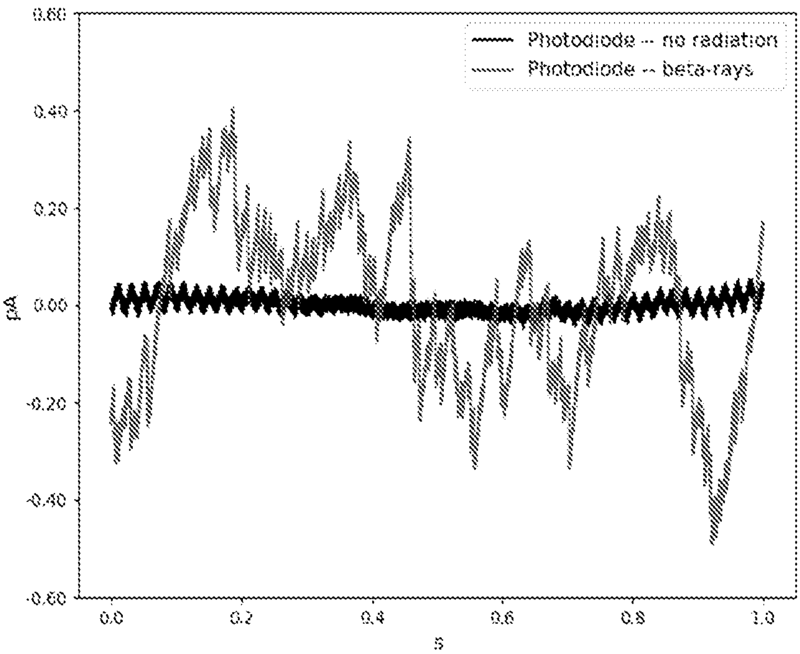
Photodiode -- no radiation
Photodiode -- beta-rays
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
μA
0.0
0.2
0.4
0.6
0.8
1.0
s

Fig.3