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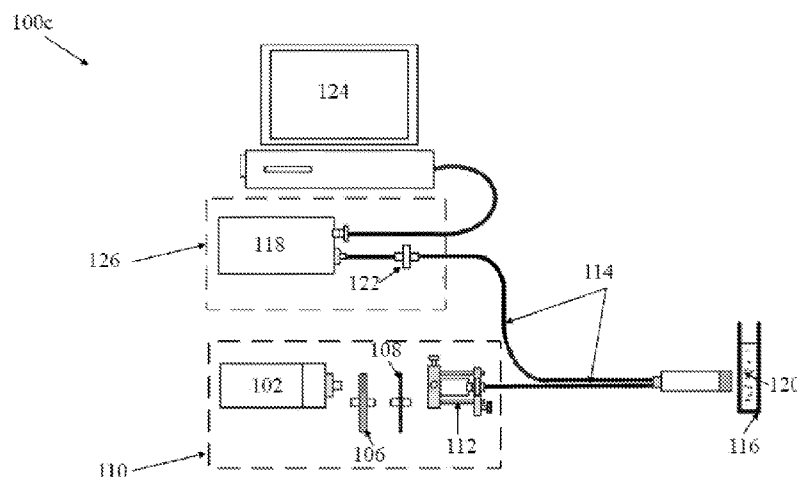


Fig. 1c

(57) Abstract: The present invention relates to a system and a method to detect and quantify DSSP molecule in a sample for predicting root resorption. The system (100c, 100d) includes a light source unit (110) configured to generate weak optical light pulse, a DSSP sample storage unit (116) configured to allow interaction of the weak optical light pulse with a DSSP sample (120) wherein specific wavelength photon of the optical pulse is absorbed by DSSP molecule of the sample, a photodetector (126) configured to receive reflected unabsorbed photon of the optical light pulse from the sample storage unit, and a computing means (124) for calculating optical light pulse with unabsorbed photons and translating it to an average photon per pulse value.



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SYSTEM AND METHOD TO DETECT AND QUANTIFY A DSSP MOLECULE IN A SAMPLE

FIELD OF INVENTION

- 5 [0001] The present invention generally relates to prediction of root resorption. More particularly, the invention relates to a system and a method to detect and quantify a Dentin Sialophosphoprotein (DSSP) molecule in a Dentin Sialophosphoprotein (DSSP) sample.

BACKGROUND OF THE INVENTION

- 10 [0002] Root resorption is loss of dental hard tissue and cementum, as a result of clastic activities. However, the dental hard tissue does not usually undergo resorption, except in situation of inflammation and trauma. Various studies have indicated that root resorption causes tooth dentine because of shorter than its original size. About 20 to 100% of patients who undergo orthodontic treatment develop root resorption, generally root resorption may be
15 described as mild, moderate and severe. Usually, it is mild condition and clinically insignificant. Severe root resorption may be harmful to the patients as it may lead to tooth extraction. Orthodontic treatment related-risk of root resorption include treatment duration, magnitude of applied force, direction of tooth movement, amount of apical displacement and method of force application (continuous vs intermittent, type of appliance and treatment technique). Besides
20 that, individual susceptibility also is considered as major factor in determining root resorption potential with or without orthodontic treatment.

- [0003] Radiographic assessment is essential in the early diagnosis of root resorption. Current dental practices commonly use 2-Dimensional (2D) radiologic imaging as standard of care.
25 There are a few 2D techniques that have been used for differential diagnosis of root resorption, including periapical, occlusal, panoramic and cephalometric radiography or a combination of these approaches. Also, panoramic radiography may be used in dental practices for early diagnosis of root resorption as it has few advantages compared to normal computed tomography, with relatively low radiation exposure, less patient chair time, easy to use, less

operator time, better patient cooperation, lower cost, lower access thresholds and availability in most dental offices. However, panoramic radiograph also has limitations, as it is difficult for detection of early or mild root resorption cases because of 2D method. Diagnosing root resorption at early stage requires 3D information using computer tomography (CT). However, CT is rather expensive, and the radiation dose is much higher than 2D radiography, it also unethical to expose patients to high dose of radiation. Furthermore, CT is not readily available for all dentists and require a trained radiologist for 3D image interpretation. Currently, cone-beam computer tomography (CBCT) is a sensitive method that allows reduced radiation exposure and better treatment result. This method is easy to use, has shorter acquisition times, feature high resolution, and low cost compared to conventional CT. Therefore, CBCT is preferable to other radiographic methods for visualizing the maxillofacial region and more sensitive for diagnosing root resorption.

[0004] External apical root resorption is an over resorption of cement that causes loose teeth or even loss of teeth. This is a common sequela of patients who receive orthodontic treatment. X-ray is the traditional method to diagnose root resorption which is often at a late stage.

[0005] There have been continuous efforts to find biological markers for root resorption for periodic monitoring, which provides a safer method compare to limitation of radiograph. Biological markers allow orthodontists to identify risk factor for root resorption before starting orthodontics treatments.

[0006] One prior art document CN 103233076B discloses a method for real-time quantitative PCR detection of a guinea pig incisors in DSSP gene, which consists of the following steps, preparing A, sample: a tooth extractor, cryogenic embrittlement process 24 to 48 h; B, primer design, C, Extraction of total RNA: Production, G, fluorescence quantitative optimization, F, a standard curve D, to establish a reaction system, E, the analysis of the reaction conditions. This method can be used for cutting teeth in a batch DSSP gene real-time PCR detection.

[0007] Another prior art WO2006059727A discloses a method comprising immobilizing a protein on a protein array substrate at a high density under regulating the orientation, irradiating the immobilized protein with ultraviolet light, visible light or infrared light, measuring the light

not absorbed by the protein to thereby detect the protein on the substrate and further analyzing an interaction between the protein on the substrate and another protein and/or a compound other than proteins and an apparatus therefor, and to provide a protein array suitable for the above described system.

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[0008] However, none of the prior arts addresses the problem of detection or prediction of root resorption in patients. In the view of foregoing, there is a need for an improved method and system for overcoming the short comings associated with prior arts.

10 SUMMARY OF THE INVENTION

[0009] Accordingly, the present invention provides a method to detect and quantify DSSP molecule in a sample. The method includes preparing weak optical light pulse using attenuated light source and optical chopper, preparing a DSPP sample and allowing the weak optical light pulse to interact with the sample, in response to interaction of the weak pulse with the sample, absorbing by the DSSP molecule a specific wavelength photon of the optical pulse and reflecting unabsorbed photon optical pulse to a photodetector, detecting intensity of the reflected unabsorbed photon optical pulse wavelength and generating a matrix, and plotting a graph using eigen values determined from the matrix, wherein the eigen value indicates a corresponding concentration of DSSP molecule.

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[00010] In an embodiment, the present invention provides a system to detect and quantify DSSP molecule in a sample. The system includes a light source unit configured to generate weak optical light pulse, a DSSP sample storage unit configured to allow interaction of the weak optical light pulse with a DSSP sample wherein specific wavelength photon of the optical pulse is absorbed by DSSP molecule of the sample, a photodetector configured to receive reflected unabsorbed photon of the optical light pulse from the sample storage unit, and a computing means for calculating optical light pulse with unabsorbed photons and translating it to an average photon per pulse value.

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[00011] The DSSP detection method uses weak pulse containing photons and analyze the correlation at different wavelengths (multidimensional). Advantageously, the system and method of the present invention detects an early root resorption at the presence of a very low DSSP concentration extracted from patient's GCF. Since, DSSP is a complex protein combination of two chain proteins namely dentin phosphoprotein (DPP) and dentin sialoprotein (DSP), amino acids that make up these proteins absorb the energy from the photons in which the absorption depends on relative concentration of the amino acids. The relative absorption indicates the types of chemical bond exist in the amino acid. Different types of chemical bond within the protein complex molecule structure such as peptide bond are absorbed at different energy frequency (wavelength). Thus, method using weak pulses and the correlation between different absorbed wavelengths provide an accurate and very sensitive absorption process information compared to by using a bright light. Three wavelengths in ultra violet region have been checked by using the spectrometer which have been identified to be absorbed by the DSSP.

BRIEF DESCRIPTION OF THE DRAWINGS

[00012] The other objects, features and advantages will occur to those skilled in the art from the following description of the preferred embodiment and the accompanying drawings in which:

[00013] Fig. 1a shows a graph of Poisson distribution in accordance with an embodiment of the present invention.

[00014] Fig. 1b shows a DSSP spectral absorption graph using high resolution spectrometer in accordance with an embodiment of the present invention.

[00015] Fig. 1c shows a system with reflective mode detection and quantification of DSSP molecule in a sample for predicting root resorption in accordance with an embodiment of the present invention.

[00016] Fig. 1d shows a system with transmissive mode detection and quantification of DSSP molecule in a sample for predicting root resorption in accordance with an embodiment of the present invention.

[00017] Fig. 2 shows a graph of photon absorbed (miu) vs DSSP concentration in accordance with an embodiment of the present invention

[00018] Fig. 3 shows a matrix data for determining eigen values in accordance with an embodiment of the present invention.

[00019] Fig. 4 shows a linear two-dimensional (2D) graph of eigen value against the DSSP concentration in accordance with an embodiment of the present invention.

5 [00020] Fig. 5 shows a flowchart depicting a method to detect and quantify a DSSP molecule in a sample in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[00021] Various embodiment of the present invention provides a system and a method to detect
10 and quantify DSSP molecule from a sample. The following description provides specific details of certain embodiments of the invention illustrated in the drawings to provide a thorough understanding of those embodiments. It should be recognized, however, that the present invention can be reflected in additional embodiments and the invention may be practiced without some of the details in the following description.

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[00022] The various embodiments including the example embodiments will now be described more fully with reference to the accompanying drawings, in which the various embodiments of the invention are shown. The invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these
20 embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the sizes of components may be exaggerated for clarity.

[00023] It will be understood that when an element or layer is referred to as being “on,”
25 “connected to,” or “coupled to” another element or layer, it can be directly on, connected to, or coupled to the other element or layer or intervening elements or layers that may be present. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[00024] Spatially relative terms, such as “source,” “light beam,” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the structure in use or operation in addition to the orientation depicted in the figures.

[00025] Embodiments described herein will refer to plan views and/or cross-sectional views by way of ideal schematic views. Accordingly, the views may be modified depending on simplistic assembling or manufacturing technologies and/or tolerances. Therefore, example embodiments are not limited to those shown in the views but include modifications in configurations formed on basis of assembling process. Therefore, regions exemplified in the figures have schematic properties and shapes of regions shown in the figures exemplify specific shapes or regions of elements, and do not limit the various embodiments including the example embodiments.

[00026] The subject matter of example embodiments, as disclosed herein, is described with specificity to meet statutory requirements. However, the description itself is not intended to limit the scope of this patent. Rather, the inventors have contemplated that the claimed subject matter might also be embodied in other ways, to include different features or combinations of features similar to the ones described in this document, in conjunction with other technologies. Generally, the various embodiments including the example embodiments relate to a system and a method to detect and quantify DSSP molecule in a sample.

[00027] In an embodiment, the present invention provides detection (the presence of DSSP) and the quantification (the DSSP concentration) from a calculation analysis method. The method utilizes a weak coherent pulse from deuterium light source with an average photon per pulse, μ (miu) below than 0.1 probability shown in graph 100a of Fig. 1a in accordance with an embodiment of the present invention. This photon source is prepared using attenuated light

source with controlled mean photon number per pulse, μ in accordance to a Poisson distribution. The probability number of photon distribution in the optical pulses is given by the following relationship; where the probability, P depends on number photon, n and average photon number per pulse, μ . The weak pulse is measured using photon counting detector module at the specific wavelength using optical bandpass filter to achieve a very precision measurement. In general, only a low consumption protein DSSP sample can be extracted from a patient which is below than 100 μL (microliter). In this extracted sample, which contains a very low concentration of DSSP is produced by the body as an early indication of having a root resorption. It is known that protein normally absorbs photon in UV wavelength region. Fig. 1a, shows graph 100a of Probability distribution according to Poisson for average photon number, $\mu = 0.1$. Note that only 10% will have non-zero photon per pulse include single and multi-photons pulses.

[00028] Referring to Fig. 1b, DSSP spectral absorption graph 100b using high resolution spectrometer is shown in accordance with an embodiment of the present invention. The spectral absorption of DSSP is measured by a high-resolution spectrometer. Two wavelength peaks indicate the presence of DSPP before each wavelength measured its intensity.

[00029] The intensity is measured using a system (100c, 100d) as shown in Fig. 1(c) and Fig. 1(d) in accordance with an embodiment of the present invention. The system shows a setup layout where the sample is placed in a 1mm path length quartz cuvette and is characterized by the free space or using optical fiber probe via transmissive or reflective detection mode. The apparatus is either in a free space setup or using a waveguide consists of three main components: a light source unit (110) to generate weak pulse, a sample storage unit (120) preferably a quartz cuvette with UV permeable spectrum to place or hold an aqueous DSPP sample in static position and a photodetector (126) with an optical bandpass filter (122).

[00030] The layout in Fig. 1c on DSSP measurement is in reflective mode. In reflective mode method, the optical setup uses optical fiber (114) as a waveguide. The optical fiber (114) in a form of a bifurcated optical probe is used to guide the attenuated light source unit (110) onto the DSSP sample (120) and guide the reflection light beam back to a photodetector (126). The attenuated light source (110) produces a weak optical pulse approaching single photon source

as accordance to the Poisson distribution formula. A deuterium lamp (102) is used in the system to produce an ultra violet light source between 200nm to 450nm wavelength. A collimator (104) may be used to collimate the source into a light beam. The light beam passes through the variable attenuator (106) to attenuate the light beam and an optical chopper (108). The optical
5 chopper (108) transforms the continuous weak light beam into optical light pulses called weak optical pulse.

[00031] In an exemplary embodiment, the light beam needs to be attenuated to generate weak optical pulses and can be controlled mechanically or electronically. It is not limited to use
10 passive optical components such as coated lenses, natural density filters or optical fiber. Further, the light source may be triggered electronically or using the optical chopper (108) to generate an optical pulse.

[00032] In an embodiment, the weak optical pulses generated guided onto the DSSP sample is
15 optimized for the reflected photon detected by the photodetector (126).

[00033] In an embodiment, the waveguide/optical probe is not limited to a bifurcated or multi-furcated optical fiber.

20 [00034] In an embodiment, the sample storage that holds DSSP sample and allows spectral transmission of the said light source is not limited to a cuvette (116).

[00035] In an exemplary embodiment, the photodetector (126) sensitive to spectral range to light source and can detect single photon optical pulse is not limited to a single photon detector,
25 photon counting module and photo multiplier tube (PMT). It shall be apparent to a person skilled in the art that different configuration and set up of photodetector may be used for detection and counting of the photon in DSSP molecule.

[00036] In an embodiment, the distribution number of photon in each optical pulse is
30 statistically governed by the Poisson formula. Ideally, each optical pulse should consist probably one photon at a time or an average photon per pulse equal to 1, where $P(n,u) = 1$. However, the probability shows some of these optical pulses may have multi-photon in them.

If these processes done in a free space medium, the weak optical pulses generated must be coupled onto the optical fiber via a fiber coupling (112). The optical fiber (114) will form an optical probe which functions as a waveguide to guide the weak optical pulses onto the DSSP sample (120). The DSSP sample (120) is placed in a special DSSP sample storage unit or cuvette (116) which is able to hold a very little amount of DSSP sample (120).

[00037] In an exemplary embodiment, the cuvette (116) allows the optical pulses to pass through and interact with the DSSP sample (120). Photons with 231nm and 275nm wavelength are absorbed by the DSSP molecules. The amount of photons absorbed is proportional to the DSSP molecules concentration. The remaining photons is reflected to the photodetector (126) through the optical probe (114). The photodetector (126) consists of a very sensitive single photon detector or a single photon counting module (118) that detects the reflected photons from the sample.

[00038] In an embodiment, the bandpass filter (122) is placed after the light source (102) and before the counting module (118), in which the photodetector (126) only detects the photons at the specific absorbent wavelength. The bandpass filter discriminates the absorbed wavelength. A computing device (124) calculates the optical pulses which contain the remaining photons and translate it to the average photon per pulse value.

[00039] The system layout in Fig. 1(d) on DSSP measurement in is transmissive mode. The free space optical setup in Fig. 1(d) is similar to fiber based optical setup in Fig. 1(c) except for the placement of fibre coupling component/arrangement. The intensity is optimized until it reaches the average photon per pulse, μ which is equal to 0.1 in order to reduce probability of multi photon in each optical pulses.

[00040] Referring to Fig. 2, a graph 200 of photon absorbed (μ) vs DSSP concentration is shown in accordance with an embodiment of the present invention.

[00041] In an exemplary embodiment, the method of the present invention provides a data prediction platform including a detection and quantification system optical setup, measuring wavelength absorption intensity of DSSP, and analyzing data correlation.

[00042] In an embodiment, the light source (102) provides light beam and is not limited to a coherence and incoherence types of light source such as deuterium lamp, LED or multiple wavelength lasers.

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[00043] In an embodiment, the system of the present invention may use a multi-furcated optical fiber to probe three DSSP absorption wavelengths simultaneously.

[00044] In an embodiment, the computing means of the present invention analyzes data correlation, where a set of DSSP samples is prepared and placed in the cuvette (116) for different DSSP concentration including a minimum and a maximum concentration to test on three absorbance wavelengths of DSSP.

[00045] In an embodiment, a minimum DSSP concentration sample or sample without DSSP is set so as archive the maximum reflected photons to the photodetector.

[00046] In an embodiment, a set of normalized reflected photon count is set against each minimum and maximum DSSP concentration to form a matrix data each that incorporates the three absorbance wavelengths simultaneously as shown by matrix 300 in Fig. 3. The solution of the matrix data provides an eigen value corresponding to each set of DSSP concentration. The data is analyzed and a linear two-dimensional (2D) graph of eigen value is plotted against the DSSP concentration as shown by graph 400 in Fig.4.

[00047] In an exemplary embodiment, the plotted graph provides a prediction platform for unknown DSSP concentration sample based on calculated eigen value.

[00048] In an example embodiment, since, the present invention is based on DSSP detection method using weak pulse non-ionization radiation with multi-dimensional (wavelengths) spectral analysis, the inversed intensity of each wavelength (in proton count probability) is recorded at least 3 times to form a 3x3 matrix table. The invention provides two matrices table which represent a recorded measurement of the maximum DSSP sample extracted from a

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patient that has a severe root resorption and a sample with a very low DSSP concentration of a healthy patient. The maximum intensity detected by the single photon detector means very minimal photon is absorbed as very less DSSP molecules is present in the sample. The matrix solution is calculated using linear algebra to find the eigen value. The eigen value shows a correlation between the recorded measurements of the three wavelengths. The two matrices provide each a set of eigen value from the maximum DSSP sample and the sample without the DSSP. The set of lower eigen value indicates the sample with very low DSSP concentration, and a set of higher eigen value indicates the sample with the most DSSP concentration. The maximum eigen value of each set is recorded to plot the linear graph, the eigen value against the DSSP concentration. This provides a reference platform for an unknown DSSP sample concentration from orthodontic patient to determine the root resorption severity.

[00049] In an exemplary embodiment, the method of the present invention is depicted in flowchart 500 as shown in Fig. 5. The method includes the steps of S502 preparing weak pulse using attenuated deuterium light source according to Poisson distribution. In S504 setting up the absorption measurement apparatus and measuring the reflected photon for single wavelength using optical filter or the like before the photon counting detector. In S506 set average photon count per pulse of reflected photon to maximum value from the sample at a very low DSSP concentration in the cuvette. In S508 inverse and normalize the measured value of average photon count per pulse of reflected photon to plot a linear graph for one single wavelength. In S510 step 508 is repeated for another two specific wavelengths, where the number of measurements taken are the same as the number of wavelengths selected. In S512 setting average photon count per pulse of reflected photon to minimum value from the sample cuvette containing for protein buffer with the most DSPP concentration and steps S508 and S510 are repeated. In S514 forming a matrix table each from all the measurements of different wavelengths to find the maximum eigen value from linear algebra solution of the matrix operation for the two difference DSSP concentration. In S516 plotting a linear graph of eigen values against DSSP concentration.

[00050] As would be apparent to a person having ordinary skilled in the art, the afore-described methods and systems may be provided in many variations, modifications or alternatives to

existing methods and systems. The principles and concepts disclosed herein may also be implemented in various manner which may not have been specifically described herein but which are to be understood as encompassed within the scope of the appended claims.

CLAIMS

1. A method to detect and quantify Dentin Sialophosphoprotein, DSSP molecule in a sample comprises the steps of:

preparing weak optical light pulse using attenuated light source and optical chopper;

5 preparing a DSPP sample and allowing the weak optical light pulse to interact with the sample;

in response to interaction of the weak pulse with the sample, absorbing by the DSSP molecule a specific wavelength photon of the optical pulse and reflecting unabsorbed photon optical pulse to a photodetector;

10 detecting intensity of the reflected unabsorbed photon optical pulse wavelength and generating a matrix, and

plotting a graph using eigen values determined from the matrix,

wherein the eigen value indicates a corresponding concentration of the DSSP molecule.

2. The method as claimed in claim 1 wherein the intensity of the reflected unabsorbed photon optical pulse wavelength is recorded multiple times.

3. The method as claimed in claim 2 wherein a maximum intensity detected by a single photon detector means a very minimal photon is absorbed hence very less DSSP molecule exist in the sample.

4. The method as claimed in claim 1 wherein an average photon count per pulse of reflected photon is set to maximum value of 0.1 for a sample cuvette containing protein buffer without DSSP.

5. The method as claimed in claim 4 wherein an absorption measurement apparatus is set up to measure the reflected photon.

6. The method as claimed in claim 1 wherein an average photon count per pulse of reflected photon is set to a minimum value for a sample cuvette containing protein buffer with maximum DSSP concentration.

7. The method as claimed in claim 1 wherein a number of measurements of the reflected photon is more than or the same as the number of wavelengths selected.

8. The method as claimed in claim 6 further comprising the step of plotting a graph for a linear algebra solution of matrix against different DSSP concentration.
9. The method as claimed in claim 1 wherein the type of amino acid present in the DSSP sample absorbs energy from the photons depending on relative concentration of the amino acid.
10. The method as claimed in claim 1 wherein at least three wavelengths in ultra violet region are identified to be absorbed by the DSSP molecule using a spectrometer.
11. The method as claimed in claim 10 wherein a computing means calculates the optical light pulse with unabsorbed photons and translates it to an average photon per pulse value.
12. A system (100c, 100d) to detect and quantify Dentin Sialophosphoprotein, DSSP molecule in a sample, the system comprising:
 - a light source unit (110) configured to generate weak optical light pulse;
 - a DSSP sample storage unit (116) configured to allow interaction of the weak optical light pulse with a DSSP sample (120) wherein specific wavelength photon of the optical pulse is absorbed by DSSP molecule of the sample;
 - a photodetector (126) configured to receive reflected unabsorbed photon of the optical light pulse from the DSSP sample storage unit (116); and
 - a computing (124) means for calculating optical light pulse with unabsorbed photons and translating it to an average photon per pulse value.
13. The system of claim 12 wherein the light source unit (110) includes:
 - a light source (102) configured to generate a light beam;
 - a variable attenuator (106) configured to attenuate the light beam; and
 - an optical chopper (108) for transforming the attenuated light beam into weak optical light pulse.
14. The system of claim 12 further comprises a waveguide (114) configured to guide weak pulse from sample to a photodetector (126).
15. The system as claimed in claim 14 wherein the waveguide (114) is an optical fibre cable.

16. The system of claim 14 further comprises a fibre coupling component (112) configured to couple the waveguide (114) to the photodetector (126).
17. The system of claim 16 wherein the fibre coupling component (112) is configured to couple the waveguide (114) to the light source unit (110) for guiding weak pulse onto and from the sample (120) to the photodetector (126) in a reflection mode configuration.
18. The system as claimed in claim 12 wherein the photodetector (126) consists of a sensitive single photon detector or a single photon counting module (118) that detects the reflected photons from the sample (120).
19. The system of claim 18 further comprises a bandpass filter (122) placed before the photon counting module (118) to discriminate photons at specific absorbent wavelength.
20. The system of claim 13 further comprises a collimator (104) for collimating the light source (102) into the light beam.

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100a

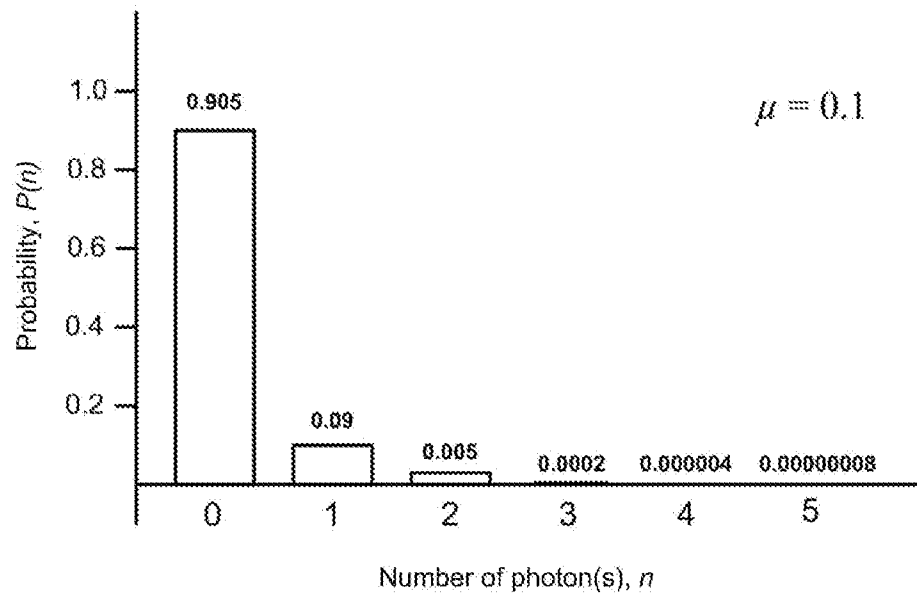


Fig. 1a

100b

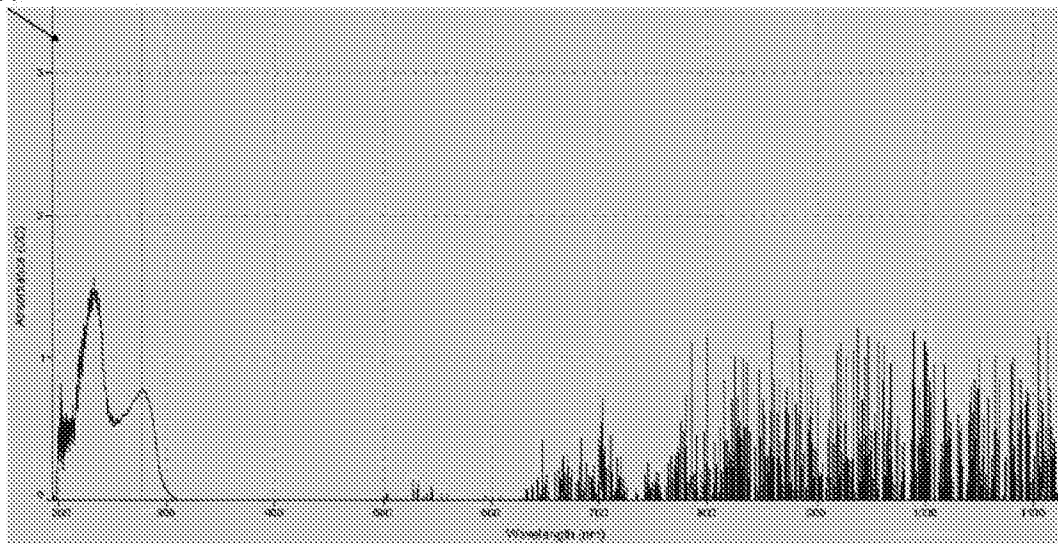


Fig. 1b

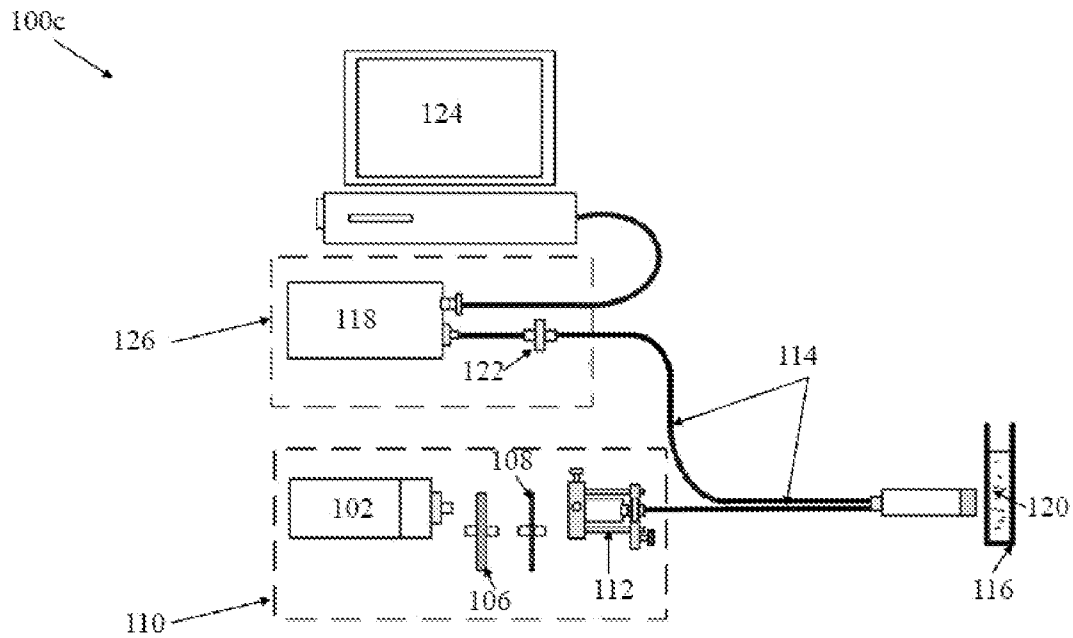


Fig. 1c

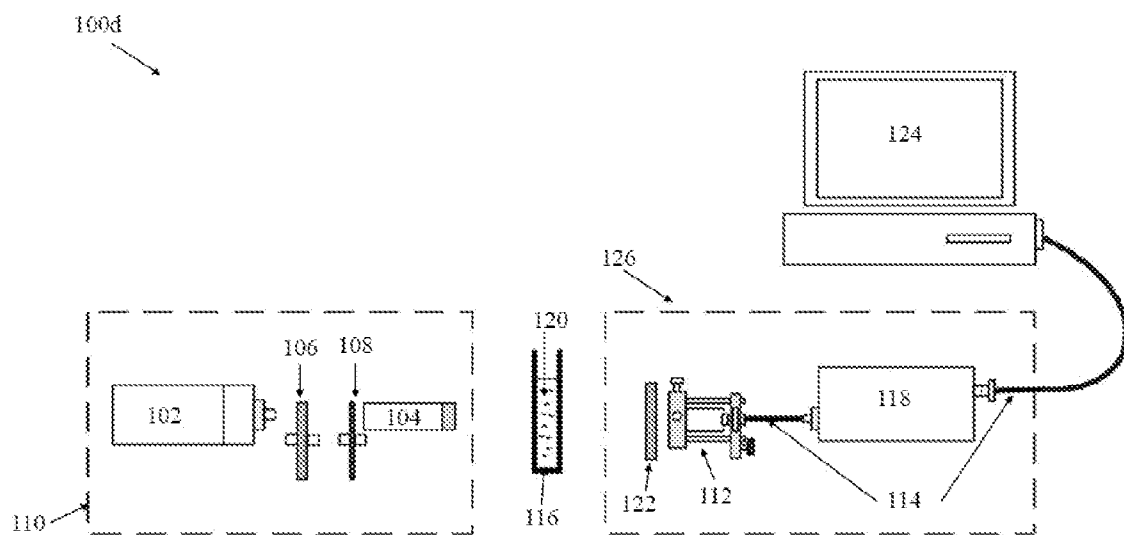


Fig. 1d

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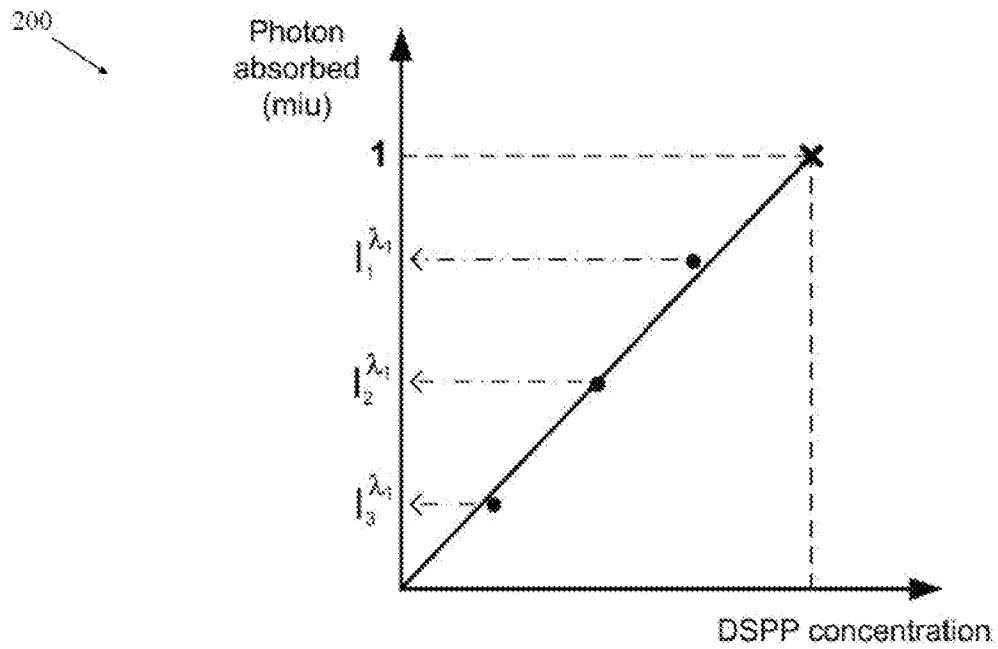


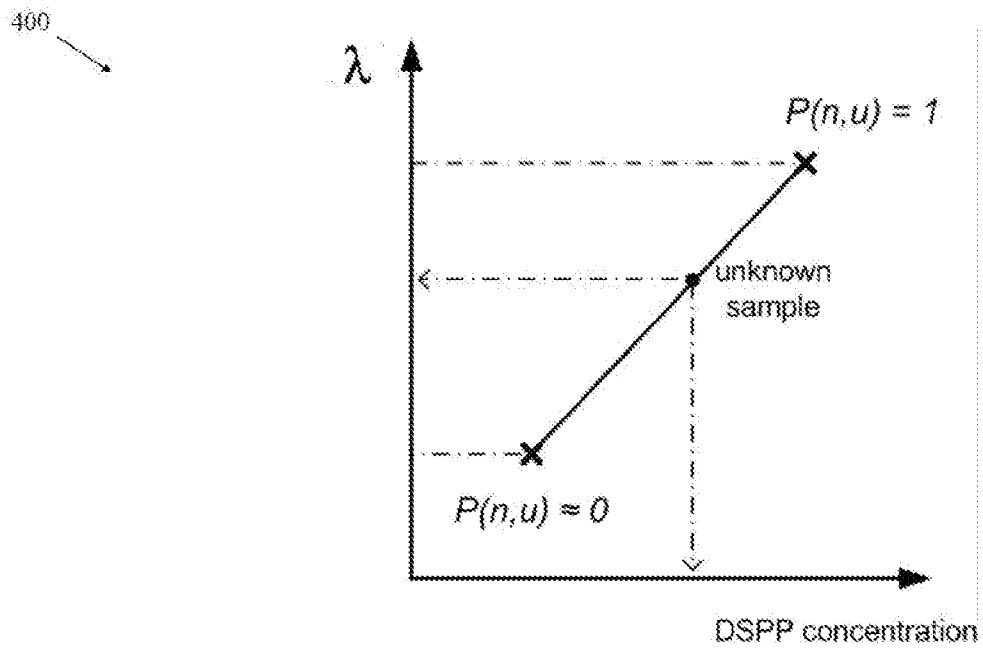
Fig. 2

300

$$A \vec{M} = \lambda \vec{M}$$

$$\begin{pmatrix} I_1^{\lambda_1} & I_1^{\lambda_2} & I_1^{\lambda_3} \\ I_2^{\lambda_1} & I_2^{\lambda_2} & I_2^{\lambda_3} \\ I_3^{\lambda_1} & I_3^{\lambda_2} & I_3^{\lambda_3} \end{pmatrix} \vec{M} = \lambda \vec{M}$$

Fig. 3

**Fig. 4**

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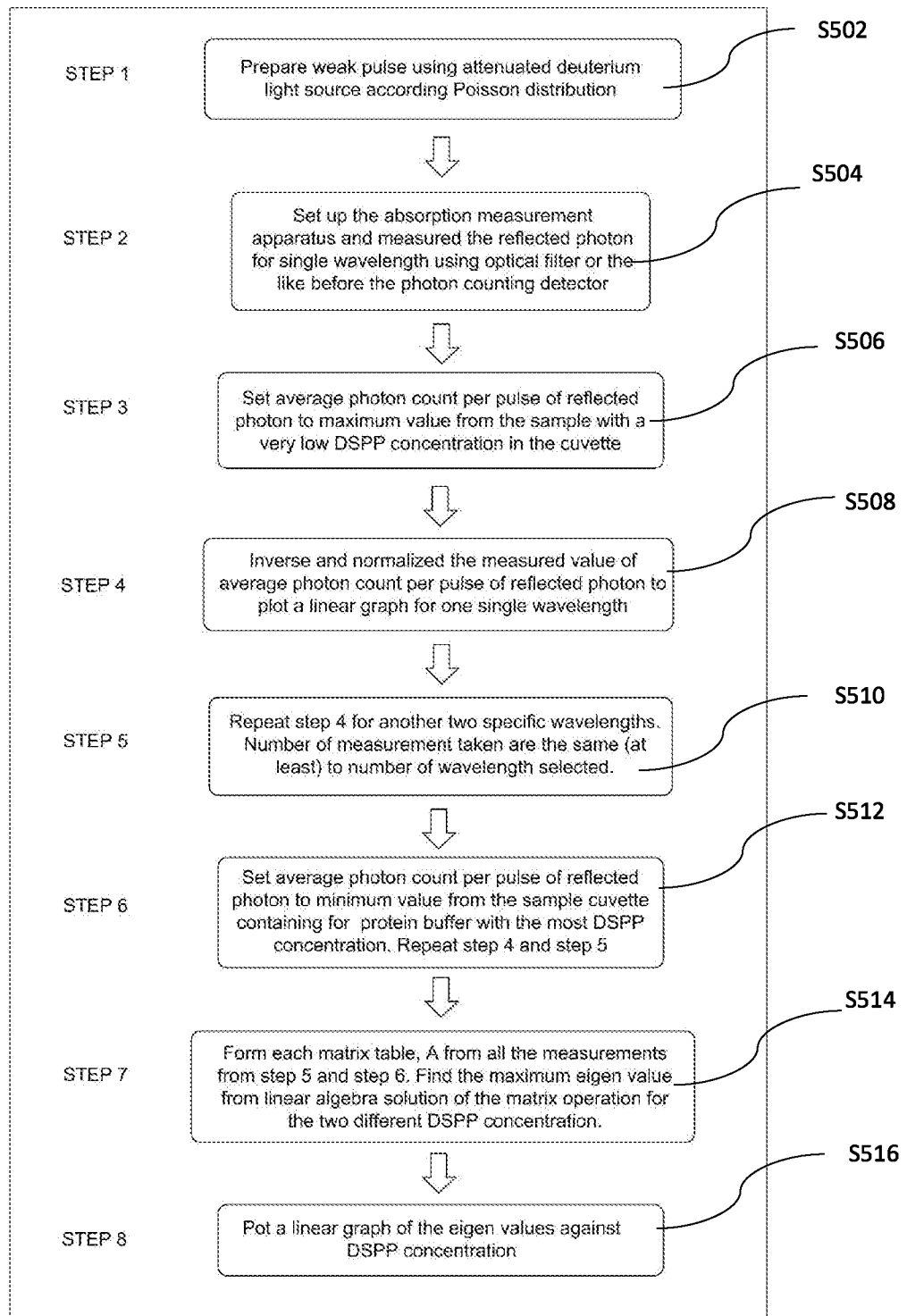


Fig. 5

A. CLASSIFICATION OF SUBJECT MATTER**G01N 15/02(2006.01)i, G01N 21/47(2006.01)i, G01N 33/487(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01N 15/02; A61K 038/46; C12N 15/09; C12N 15/11; C12Q 001/68; C12Q 1/68; G01N 21/47; G01N 33/487

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: dentin sialophosphoprotein molecule, light source unit, cuvette, photodetector, computing means, attenuator, optical chopper, waveguide, fibre coupling component, band pass filter, collimator, weak optical light pulse, photon, intensity, matrix, eigen value

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LOMBARDO, L. et al., Quantitive evaluation of dentin sialoprotein (DSP) using microbeads - a potential early marker of root resorption, ORAL & Implantology, 2016, Vol. 9, No. 3, pages 132-142 See SUMMARY; Materials and methods; Results; Discussion; Figures 1-6.	1-20
A	JP 3886901 B2 (SINOGENOMAX CO., LTD.) 28 February 2007 See the whole document.	1-20
A	UMA, H. L. et al., Identification of dentine sialophosphoprotein In gingival crevicular fluid to assess root resorption using three piece base arch, IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 2018, Vol. 17, No. 1, pages 56-63 See the whole document.	1-20
A	US 2003-0180280 A1 (KONG, X. et al.) 25 September 2003 See the whole document.	1-20
A	KR 10-1129033 B1 (KYUNGPOOK NATIONAL UNIVERSITY INDUSTRY-ACADEMIC COOPERATION FOUNDATION) 23 March 2012 See the whole document.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 September 2020 (25.09.2020)

Date of mailing of the international search report

06 October 2020 (06.10.2020)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2020/050032

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KR 10-1129033 B1	23/03/2012	KR 10-1118546 B1 KR 10-1122120 B1 KR 10-2012-0003427 A	14/03/2012 16/03/2012 10/01/2012