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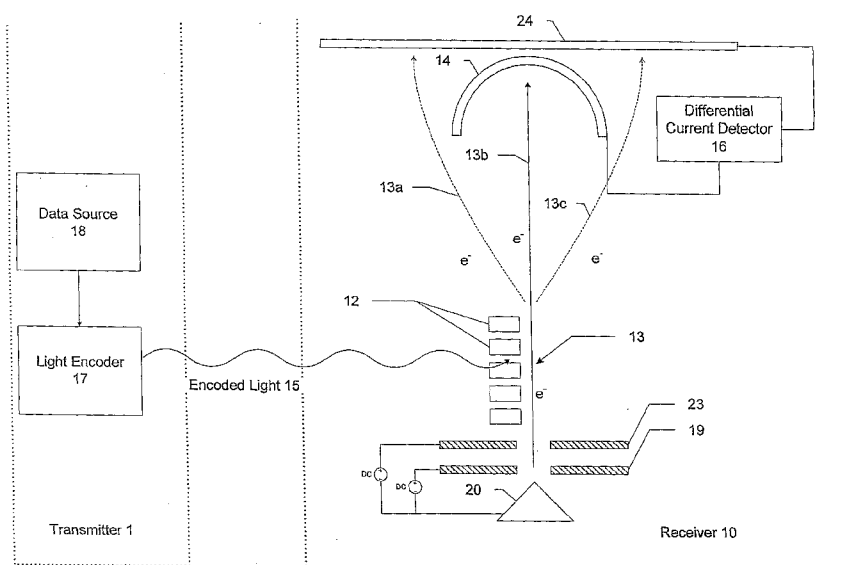
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(54) Title: RESONANT DETECTOR FOR OPTICAL SIGNALS



(57) Abstract: An electronic receiver for decoding data encoded into light is described. The light is received at an ultra-small resonant structure. The resonant structure generates an electric field in response to the incident light. An electron beam passing near the resonant structure is altered on at least one characteristic as a result of the electric field. Data is encoded into the light by a characteristic that is seen in the electric field during resonance and therefore in the electron beam as it passes the electric field. Alterations in the electron beam are thus correlated to data values encoded into the light.

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RESONANT DETECTOR FOR OPTICAL SIGNALS

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] The present invention is related to the following co-pending U.S. Patent applications which are all commonly owned with the present application, the entire contents of each of which are incorporated herein by reference:

1. U.S. Patent Application No. 11/238,991, entitled "Ultra-Small Resonating Charged Particle Beam Modulator," filed September 30, 2005;
2. U.S. Patent Application No. 10/917,511, entitled "Patterning Thin Metal Film by Dry Reactive Ion Etching," filed on August 13, 2004;
3. U.S. Application No. 11/203,407, entitled "Method Of Patterning Ultra-Small Structures," filed on August 15, 2005;
4. U.S. Application No. 11/243,476, entitled "Structures And Methods For Coupling Energy From An Electromagnetic Wave," filed on October 5, 2005;
5. U.S. Application No. 11/243,477, entitled "Electron beam induced resonance," filed on October 5, 2005;
6. U.S. Application No. 11/325,448, entitled "Selectable Frequency Light Emitter from Single Metal Layer," filed January 5, 2006;

7. U.S. Application No. 11/325,432, entitled, "Matrix Array Display," filed January 5, 2006;
8. U.S. Application No. 11/302,471, entitled "Coupled Nano-Resonating Energy Emitting Structures," filed December 14, 2005;
9. U.S. Application No. 11/325,571, entitled "Switching Micro-resonant Structures by Modulating a Beam of Charged Particles," filed January 5, 2006;
10. U.S. Application No. 11/325,534, entitled "Switching Microresonant Structures Using at Least One Director," filed January 5, 2006;
11. U.S. Application No. 11/350,812, entitled "Conductive Polymers for Electroplating," filed February 10, 2006;
12. U.S. Application No. 11/349,963, entitled "Method and Structure for Coupling Two Microcircuits," filed February 9, 2006; and
13. U.S. Application No. 11/353,208, entitled "Electron Beam Induced Resonance," filed February 14, 2006.

FIELD OF THE DISCLOSURE

[0003] This relates in general to receivers for detecting optical signals and in particular to resonant structures detecting encoded optical signals.

INTRODUCTION

[0004] It is not a simple task to modulate a light beam into an electron beam. Due to the size and dispersion of photons in the light beam and the size and dispersion of electrons in the electron beam the two rarely intersect, physically, even when the light beam and electron beam are directly crossed. There have been some physicists who have employed large scale lasers to intersect an electron beam and detected occasional scattered electron patterns caused by a few of the electrons in the beam physically intersecting with photons in the laser beam. But, the scale of such devices is large and their efficiency is poor.

[0005] In the related applications described above, micro- and nano-resonant structures are described that react in now-predictable manners when an electron beam is passed in their proximity. We have seen, for example, that the very small structures described in those applications allow energy of the electron beam to be converted into the energy of electromagnetic radiation (light) when the electron beam passes nearby. When the electron beam passes near the structure, it excites synchronized oscillations of the electrons in the structure (surface plasmons). As often repeated as the many electrons in a beam pass, these surface plasmons result in reemission of detectable photons as electromagnetic radiation (EMR).

[0006] The EMR can be modulated to encode data from a data source. The encoded EMR can then transport the data at an extremely fast data rate. Further, using resonant structures of the types described in the related applications, the transmitter can be built into a chip and used to transmit the data within a microcircuit (intra-chip) or between one or more microcircuits of one or more chips. A number of methods of encoding such data can be envisioned and is not delimiting of the inventions described herein.

[0007] We herein disclose methods and structures for receiving the encoded EMR, and decoding it to retrieve the original data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a schematic view of an encoder and decoder system;

[0009] FIG. 2 is an alternative resonant structure for a receiver;

[0010] FIGS. 3 and 4 are schematic representations of a portion of a resonant structure decoding binary "LO" and binary "HI" signals, respectively;

[0011] FIG. 5 is a perspective view of two resonant structures for a receiver;

[0012] FIG. 6 is a non-empirical, non-experimental representation of the

theoretical absorption versus wavelength for a structure such as in FIG. 5;

- [0013] FIG. 7 is an alternative example receiver;
- [0014] FIG. 8 is an alternative example receiver;
- [0015] FIG. 9 is an alternative example receiver;
- [0016] FIG. 10 is an alternative example receiver;
- [0017] FIG. 11 is an alternative example receiver;
- [0018] FIG. 12 is an alternative example receiver;
- [0019] FIG. 13 is an alternative example receiver;
- [0020] FIG. 14 is an example secondary electron shield on an example receiver;
- [0021] FIG. 15 is an example amplitude-modulated receiver;
- [0022] FIG. 16 is an example secondary detector;
- [0023] FIG. 17 is a close-up view of a portion of the secondary detector of Fig. 16;
- [0024] FIG. 18 is a representation of experimental results from a resonant receiver structure; and
- [0025] FIG. 19 is a representation of experimental results from a resonant receiver structure.

THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

[0026] A transmitter 1 can include an ultra-small resonant structure, such as any one described in U.S. Patent Application Nos. 11/238,991; 11/243,476; 11/243,477; 11/325,448; 11/325,432; 11/302,471; 11/325,571; 11/325,534; 11/349,963; and/or 11/353,208 (each of which is identified more particularly above). The resonant structures in the transmitter can be manufactured in accordance with any of U.S. Application Nos. 10/917,511; 11/350,812; or

11/203,407 (each of which is identified more particularly above) or in other ways. Their sizes and dimensions can be selected in accordance with the principles described in those applications and, for the sake of brevity, will not be repeated herein. The contents of the applications described above are assumed to be known to the reader.

[0027] Although less advantageous than the ultra-small resonant structures identified in the applications described above, alternatively the transmitter 1 can also comprise any macroscopic or microscopic light emitter, and can include even prior art LEDs, semiconductors or other light-emitting devices.

[0028] The transmitter 1 is operated in association with a data source 18, which may be part of the transmitter or may be separated from the transmitter 1 (the former embodiment is shown in Fig. 1). For purposes of this disclosure, the kind of data transmitted, the kind of EMR produced, and the kind of structure producing the EMR are not delimiting. It matters only that in some way data are encoded into an EMR beam. In the embodiment of FIG. 1, the data source 18 supplies data to a light encoder 17 that encodes the data into the light beam and transmits encoded light 15 to the receiver 10.

[0029] In the example of FIG. 1, the receiver 10 includes cathode 20, anode 19, optional energy anode 23, ultra-small resonant structures 12, Faraday cup or other receiving electrode 14, electrode 24, and differential current detector 16. The status of the receiver 10 will now be described in the case where the receiver 10 is not being stimulated by encoded light 15. In such a case, the cathode 20 produces an electron beam 13, which is steered and focused by anode 19 and accelerated by energy anode 23. The electron beam 13 is directed to pass close to but not touching one or more ultra-small resonant structures 12. In this sense, the beam needs to be only proximate enough to the ultra-small resonant structures 12 to invoke detectable electron beam modifications, as will be described in greater detail below. These resonant structures in the receiver 10 can be, by way of

example, one of those described in U.S. Patent Application Nos. 11/238,991; 11/243,476; 11/243,477; 11/325,448; 11/325,432; 11/302,471; 11/325,571; 11/325,534; 11/349,963; and/or 11/353,208 (each of which is identified more particularly above). The resonant structures in the receiver **10** can be manufactured in accordance with any of U.S. Application Nos. 10/917,511; 11/350,812; or 11/203,407 (each of which is identified more particularly above) or in other ways.

[0030] As the term is used herein, the structures are considered ultra-small when they embody at least one dimension that is smaller than the wavelength of visible light. The ultra-small structures are employed in a vacuum environment. Methods of evacuating the environment where the beam **13** passes by the structures **12** can be selected from known evacuation methods.

[0031] After the anode **19**, the electron beam **13** passes energy anode **23**, which further accelerates the electrons in known fashion. When the resonant structures **12** are not receiving the encoded light **15**, then the electron beam **13** passes by the resonant structures **12** with the structures **12** having no significant effect on the path of the electron beam **13**. The electron beam **13** thus follows, in general, the path **13b**. In the embodiment of **FIG. 1**, the electron beam **13** proceeds past the structures **12** and is received by a Faraday cup or other detector electrode **14**. As is well-known, the Faraday cup will receive and absorb the electron beam **13**. In alternative embodiments, the path of the electron beam can be altered even when the encoded light **15** is not being received at the resonant structures, provided the path of the electron beam **13** is identifiable with the absence of the encoded light **15**.

[0032] Next, we describe the situation when the encoded light **15** is induced on the resonant structures **12**. Like the earlier scenario, the cathode **20** produces the electron beam **13**, which is directed by the current anode **19** and energy anode **23**, past the resonant structures **12**. In this case, however, the encoded light **15** is

inducing surface plasmons to resonate on the resonant structures **12**. The ability of the encoded light **15** to induce the surface plasmons is described in one or more of the above applications and is not repeated herein. The electron beam **13** is impacted by the surface plasmon effect causing the electron beam to steer away from path **13b** (into the Faraday cup) and into alternative path **13a** or **13c**. Note that the dimensions in **FIG. 1** are not to scale—the amount of deflection of the electron beam may be exaggerated in **FIG. 1** to illustrate the principle. The size of the Faraday cup or other detector electrode **14** is selected so the deflected electron beam on path **13a/13b** misses the Faraday cup and instead is received at the electrode **24**. Differential current detector **16** detects when the electron beam **13** is impacting the electrode **24** by detecting a differential current between the Faraday cup or other detector electrode **14** and the electrode **24**. Alternative methods of detecting the deflected electron beam other than the Faraday cup and electrode will be recognizable to the artisan who understands from this description the structure and purpose of the receiver **10**.

[0033] Many alternative structures and arrangements are available for the various components shown in **FIG. 1**. For example, resonant structures **12** can appear on one side of the electron beam **13**, as shown, or may appear on both sides of the electron beam **13** so the electron beam path is impacted by resonant structures as it passes between them. An example such structure is shown in **FIG. 2**. There, the resonant structures are no longer rectangular shaped (the structures could conceivably be any shape), but are instead triangular. The triangular shape may be preferable in altering the passing electron beam **13** due to concentration of the electromagnetic fields in the tips of the triangles as the surface plasmons are excited by the incident light **15**.

[0034] As is generally known, the encoded light **15** will not interact with the electron beam directly. That is, the electrons in the beam are so small and so dispersed and the photons of the light **15** are small and dispersed that practical

interaction between them is essentially a statistical non-existence. The general belief is that direct transfer of the information in the encoded light 15 with the highly dispersed electron beam is impractical if not impossible. Although the encoded light 15 cannot be reliably transferred to the electronic structures of the receiver 10 by simple interaction of the light 15 with the electron beam 13, we have provided a receiver that “holds” the information in the light on the resonant structures 12 via the activity of the surface plasmons long enough for the electron beam 13 passing by to interact with light 15 and couple the data content. The information encoded in the light 15 is thus coupled onto the electron beam 13 (and thus to electronic circuit elements) when it was previously considered impossible to do so.

[0035] The light 15 can be encoded with the data from the data source 18 in a variety of ways, but one example way is now described. The light 15 can be encoded by pulses, such that a light “OFF” condition indicates a binary “0” bit condition from the data source 18 and a light “ON” condition indicates a binary “1” bit condition from the data source 18. The encoded light 15 sent to the receiver is then a set of pulses indicating binary data information. The response of the receiver resonant structures 21 is illustrated in FIGS. 3 and 4.

[0036] In FIGS. 3 and 4, for simplicity we illustrate only one of the resonant structures 21, but the artisan will recognize from the disclosure with respect to FIGS. 1 and 2 that more than one such structure can be presented in the receiver 10. FIG. 3 illustrates the electron beam 13 passing by the resonant structure 21 when the encoded light 15 is “OFF,” i.e., a “0” binary bit condition from the data source 18. As shown, the lack of incident light from the encoded light beam 15 (an “off pulse”) produces no appreciable effect between the resonant structure 21 and the passing electron beam 13. Accordingly, the electron beam 13 passing generally straight along path 13b and into the Faraday cup or other detector electrode 14.

[0037] FIG. 4 illustrates the electron beam 13 passing by the resonant structure 21 when the encoded light 15 is "ON," i.e., a "1" binary bit condition from the data source 18. In this case, the light 15 is incident to the resonant structure 21. The resonant structure 21 responds to the light 15 with the surface plasmons moving on the surface 25 and creating a focused electric field at the tip of the triangular structure 21. The electric field causes the passing electron 13 to alter its otherwise straight path to the alternative path 13a. As described earlier, the path 13a takes the electron beam past the Faraday cup or other detector electrode 14 and onto the electrode 24, where the electron beam is detected by the differential current detector 16. Alternatively to directing the electron beam to one of the paths 13a or 13c, the path of the deflected electron beam 13 could be a scattering along multiple paths including paths 13a and 13c, as the resonating effect of the light 15 on the structures 21 changes the electric field at the tip. In such a case, using the embodiment of FIG. 1, the altered paths will each miss the detector 14 and thus the resonance on the structure 21 will still cause the electrons to meet the electrode 24 rather than the electrode 14.

[0038] As described, the "ON" condition of the light 15 is reflected in a detection of a current difference in the differential current detector 16 caused by the deflection of the electron beam 13 into the electrode 24 rather than the detector electrode 14. A pulse "OFF" condition of the light 15 is reflected in a detection of a different differential current value in the differential current detector 16 when the electron beam 13 is directed straight into the Faraday cup or other detector electrode 14.

[0039] Recognizing now how the receiver 10 can decode the "0" and "1" conditions, the artisan can readily appreciate how the encoder 17 can encode the data from the data source 18 by pulsing the light on for one of the binary conditions and off for the other of the binary conditions.

[0040] In general, a resonant structure 12 and/or 21 will respond most

effectively to a particular frequency of light. In a preferred arrangement, the transmitter transmits light at a particular wavelength and the resonant structures **12** and **21** have geometries that respond to that wavelength. **FIG. 6** illustrates the general principle (it is not reflective of any actual test) that ultra-small structures of particular geometries, such as those shown in **FIG. 5** (showing height, width, depth and periodicity of resonant structures) will demonstrate absorption rates peaking at multiples of a particular wavelength. Those absorption rates will correlate to the strength of the electric fields produced at the points of the triangle resonant structures **21** or other-shaped structures **12**, and thus will correlate to the effect that the light **15** has on the passing electron beam **13**. The present receiver **10** is not limited to any particular resonant structure shape (many example shapes are described in the related patent applications identified above), but should preferably (though not necessarily) have one dimension smaller than the wavelength of the photon to be produced.

[0041] For any given structure, the wavelength characteristics shown in **FIG. 6** can be ascertained for any given structure by empirically testing the structure. Applying light of varying frequencies and measuring the absorption characteristics leads to a kind of the graph of **FIG. 6** for any particular structure type, size, and periodicity. Once the characteristic frequency of absorption is ascertained, it can either be adjusted to the frequency of the encoded light **15**, or the encoded light **15** can be adjusted in frequency to that of the receiver **10**.

[0042] One example empirical graph is shown in **FIG. 18** where the Y-axis represents counts of electrons detected versus finger length (i.e., the long dimension of resonant structure). The resultant peaks illustrate optimal finger lengths for the particular light frequency and can be used to shape the geometry of the resonant structures to optimally couple the light beam **15**.

[0043] **FIGS. 7-13** illustrate different forms of receivers that provide the same mechanism of decoding of the encoding light **15**. In **FIG. 7**, the electrode

14a corresponds to the electrode **14** in **FIG. 1**, except that the shape is flatter. **FIG. 7** illustrates the broader principle that the shape, size and characteristics of all of the electrodes shown can be modified from the ones described and shown herein and still accomplish the intended decoding.

[0044] In **FIG. 8**, two additional alternative design principles are embodied. First, the order of encounter of the electrodes can be altered; namely the “straight path” electrode **30** for the OFF condition can appear to the electron beam **13** after passing the “altered path” electrode **14b/24a** for the ON condition. In this embodiment, the electrodes **14b** and **24a** can be separate electrodes electrically connected to the detector **16**, or they can be one doughnut-shaped electrode with the hole in the center providing the path for the electron beam **13** to pass when it is not be diverted. **FIG. 8** also illustrates the alternative principle that the detector **16** need not detect the current difference between the ON and OFF electrodes, but can instead detect change in current in the ON electrode(s). In that instance, the OFF electrode (in the case of **FIG. 8** the electrode **30**) takes the electron beam to ground (or may capture it with a Faraday cup and employ it for power requirements of the electric circuits).

[0045] **FIG. 9** illustrates a detector in which the detector **16** detects current conditions on the OFF electrode **14c** and compares it to ground. It could alternatively do the same for the ON electrode (instead or in addition to the OFF electrode).

[0046] **FIG. 10** illustrates the ON electrodes **14b/24a** taking the electron beam to ground and the OFF electrode **30** providing the detector **16** with a signal referenced to ground whenever the electron beam follows the non-deflected path **13b**.

[0047] **FIG. 11** illustrates basically side-by-side electrodes **24** and **14b**. As shown, electrode **14b** slightly extends into the straight-line path **13b** so the OFF condition is detected by it. Electrode **24** is positioned to capture the electron beam

when it is deflected to the **13a** path in the ON condition.

[0048] In earlier embodiments, we described the detector referenced from an ON electrode to an OFF electrode, from an ON electrode to ground, and from an OFF electrode to ground. In **FIG. 12** we illustrate detectors that provide improved sensitivity and noise-reduction by referencing the received electron beam to the cathode. In **FIG. 12**, the principle of the detector referenced to an electric characteristic of the cathode is shown. Although not limiting, the example embodiment shows the OFF electrode **14a** receiving the OFF path **13b** and the ON electrode **24** receiving the ON paths **13a** and **13c**. In general, when the electron beam follows the path **13b**, the detector receives the beam and references it to an electrical characteristic that it receives from the cathode (or another element associated with the electron beam source). In that way, noise associated with the electron beam source can be cancelled. The OFF electrode can be grounded, Faraday cupped, etc. The ON electrode **24** is electrically coupled to the detector **16**. Inside detector **16** is a current detector **28** that measures the current between the cathode **20** and anode **19**. In operation, when the electron beam is deflected to the electrode **24**, the current in that electrode **24** is detected by the detector **16** (and then diverted ground, a Faraday cup, etc.) and referenced to the current detected by detector **28** such that noise in the electron beam source can be cancelled, improving detection sensitivity.

[0049] One way that that noise can corrupt the decoding process is by stray electrons bouncing from the receiving electrode (either the ON or OFF electrode) rather than being captured thereby. The shield **29a/29b** in **FIGS. 13 and 14** illustrate an example option that can reduce the strays. Specifically, it is advantageous to keep stray electrons out of the area where the electron beam **13** (either deflected or non-deflected) will be traveling to avoid collisions between the stray electrons and the electrons in the beam **13**. The shields **29a** and **29b** are grounded and sit in front of (relative to the beam path) the detector being

employed in order to provide the stray electrons another "to-ground" attraction before they enter the area where the electron beam 13 is traveling. The shields 29a and 29b can be employed with any type of detector (for example, any of FIGS. 7-12).

[0050] FIGS. 16 and 17 describe an optional electrode structure that will also better capture the electrons in the electron beam 13, thereby reducing the possibility of stray electrons returning "up-stream" and interfering with the electron beam 13. In FIG. 16, the electrode 60 (which can be any of the electrode embodiments earlier described) is in the structural form of a baffle such that approaching electrons in the beam 13 have a multiple chance of being absorbed. In FIG. 16, only the OFF electrode 60 is shown with the baffles, but the ON detector electrode 61 can also (or instead) be baffled. The baffles are more particularly shown in FIG. 17, where the electron beam 13x is shown bouncing (instead of being absorbed) on the electrode 60 and yet then be absorbed on the second encounter with the electrode 60 (after the bounce). This improves signal detection and signal-to-noise ratio, and reduces the possibility of stray electrons re-entering the area where the electron beam 13 is encountering the resonant structures 12.

[0051] FIG. 15 illustrates an AM (amplitude modulation) detector based on the above-described detector principles. As shown, the cathode, anode, and resonant structures of, for example FIG. 1, are combined into the box "Charge Source and Resonant Structures" but basically operate according to the principles outlined in Figure 1. In this case, however, the encoded light 15 contains data from the data source 18 that is modulated with more than two binary conditions. Thus, the encoded light invokes the electric field in the resonant structures in accordance with a characteristic of the light (for example, intensity, frequency, polarity, etc.) such that the electric field in the resonant structures bears an amplitude relation to the light characteristic. The data from the data source 18 can

then be encoded by the light characteristic such that greater than two data states—and indeed within the limits of practicality, infinite data states can be amplitude modulated on the data source.

[0052] Once the light characteristic is encoded, the resonant structures encountering that light **15** respond by electric field amplitude changes in accordance with the light characteristic. The electron beam **13** passing close to the resonant structures couple that amplitude characteristic and deflect at an angle commensurate with the amplitude modulation. Thus, high amplitude modulation can result in the beam diversion to path **46** and onto electrodes **32/37**, where it is detected by detector portion **45**. Lesser amplitudes result in beam path diversions to paths **47**, **48**, and **49**, respectively encountering electrodes **33/38**, **34/39** and **35/40** and detector portions **44**, **43**, and **42**. No diversion (i.e., a “0” amplitude state) results in no diversion of the beam path **13** and thus a path **50** into electrode **36** detected by detector portion **41**. It can thus be seen that “analog” differences in light characteristic can be detected by amplitude demodulation. The sensitivity of the data can be adjusted based on the number and size of the electrodes **32-40**. By adding more electrodes, a greater number of differentiated amplitude increments can be detected and thus greater data volume can be encoded.

[0053] FIG. 19 illustrates a graph of percent reflectivity (Y-axis) versus wavelength of light measured in nm (X-axis). In the experiment, different length ultra-small resonant structures were arranged on a substrate and light of different frequencies and polarities was directed near the structures. The different curves represent the degrees of polarization of the light (in 45 degree increments) relative to the long dimension of the finger length. The percent reflectivity in this experiment indicates the percent of reflection off of a surface with a resonant structure versus a surface without one, thus indicating inversely the amount of light energy absorbed by one or more of the ultra-small resonant structures located on the substrate. The dominant “dips” in the graph illustrate wavelengths of the

light that were absorbed well by one or more of the resonant structures at the polarity shown. Other light frequencies and finger lengths could be mapped and used as alternatives. The graph is significant to show that the resonant structures are in fact absorbing the encoded light energy. The graph is also significant in illustrating the effect of polarization angle on the absorption. In essence, the graph illustrates that absorption occurs and that it is enhanced when polarization of the light is parallel to the finger length. The graphs for polarization angles 0 and 180 show large absorption at the dips and for angles 90 and 270, for example show lower absorption.

[0054] From **FIG. 19**, one can ascertain various light characteristics that can be employed for linear (or non-linear) amplitude modulation employed by, for example, the structure of **FIG. 15**. Light intensity of the encoded light **15** affects electric field strength produced in the resonant structures **12** and thus can be used to angularly modulate the beam path. So too can changes in polarization and light frequency, such that they too can be used to encode the data on the light **15** to produce a corresponding path alteration in the electron beam **13** at the receiver **10**.

[0055] While certain configurations of structures have been illustrated for the purposes of presenting the basic structures of the present invention, one of ordinary skill in the art will appreciate that other variations are possible which would still fall within the scope of the appended claims. While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

CLAIMS

What is claimed is:

1. A receiver to decode data from electromagnetic radiation, comprising:
a resonant structure adjacent to, but not directly in, the path of a passing electron beam;
a first electron absorption element receiving at least a portion of the electron beam when data encoded in the electromagnetic radiation satisfies a first condition;
and
a second electron absorption element receiving at least a portion of the electron beam altered by the resonant structure when data encoded in the electromagnetic radiation satisfies a second condition distinct from the first condition.
2. The receiver according to claim 1 wherein the resonant structure is a rectangular shape or a C shape.
3. The receiver according to claim 1 wherein the resonant structure is a shape having a relatively small face to the electron beam relative to the total perimeter of the resonant structure.
4. The receiver according to claim 3 wherein the resonant structure is triangular and a point of the triangle is facing the electron beam.
5. The receiver according to claim 1 wherein the resonant structure is a shape that concentrates an electric field induced by the electromagnetic radiation near the passing electron beam.
6. The receiver according to claim 1, further including:

a detector to detect whether the electrode is receiving at least the portion of the electron beam.

7. The receiver according to claim 1, further including:

a detector to detect whether the electron absorption device is receiving the electron beam.

8. The receiver according to claim 1 wherein the first electron absorption element is a Faraday cup and the second electron absorption element is an electrode.

9. The receiver according to claim 1, further including a source of the electron beam to direct the electron beam to pass near to but not on the resonant structures.

10. The receiver according to claim 1, wherein the resonant structure has a dimension smaller than the wavelength of the electromagnetic radiation.

11. A method of decoding data encoded into electromagnetic radiation, comprising:

receiving the electromagnetic radiation at a resonant structure to cause the resonant structure to generate an electric field on a surface of the resonant structure;

producing an electron beam that passes by, but not on, the resonant structure near the surface of the resonant structure with the electric field to alter the path of the electron beam in accordance with data encoded on the electromagnetic radiation; and

decoding the data encoded on the electromagnetic radiation by detecting the path of the electron beam.

12. A method according to claim 11, further including the step of receiving the electron beam at one of a first or second receiving element depending on the binary data condition of the data encoded in the electromagnetic radiation.
13. A device, comprising:
a set of structures resonating when a particular frequency of electromagnetic radiation higher than the microwave frequency is received on the structures;
a first path to receive an electron beam along the set of structures;
a second path to receive the electromagnetic radiation around the particular frequency and encoded with data;
a detector to recognize at least two different conditions of the electron beam indicative of at least two different corresponding data values encoded in the electromagnetic radiation, at least one of the two different conditions induced on the electron beam by the set of structures resonating when the particular frequency of electromagnetic radiation higher than the microwave frequency is received on the structures.
14. The device of claim 13, wherein the set of structures is a set of ultra-small metal triangles.
15. The device according claim 13, wherein the first of the two different conditions is the detection of the electron beam at a Faraday cup.
16. The device according claim 13, wherein the second of the two different conditions is the detection of the electron beam at an electrode.
17. The device according to claim 13, wherein the two different conditions are determined by a differential detector.

18. The device according to claim 13, wherein the first of the two different conditions is a first electron beam path and the second of the two different conditions is a second electron beam path.

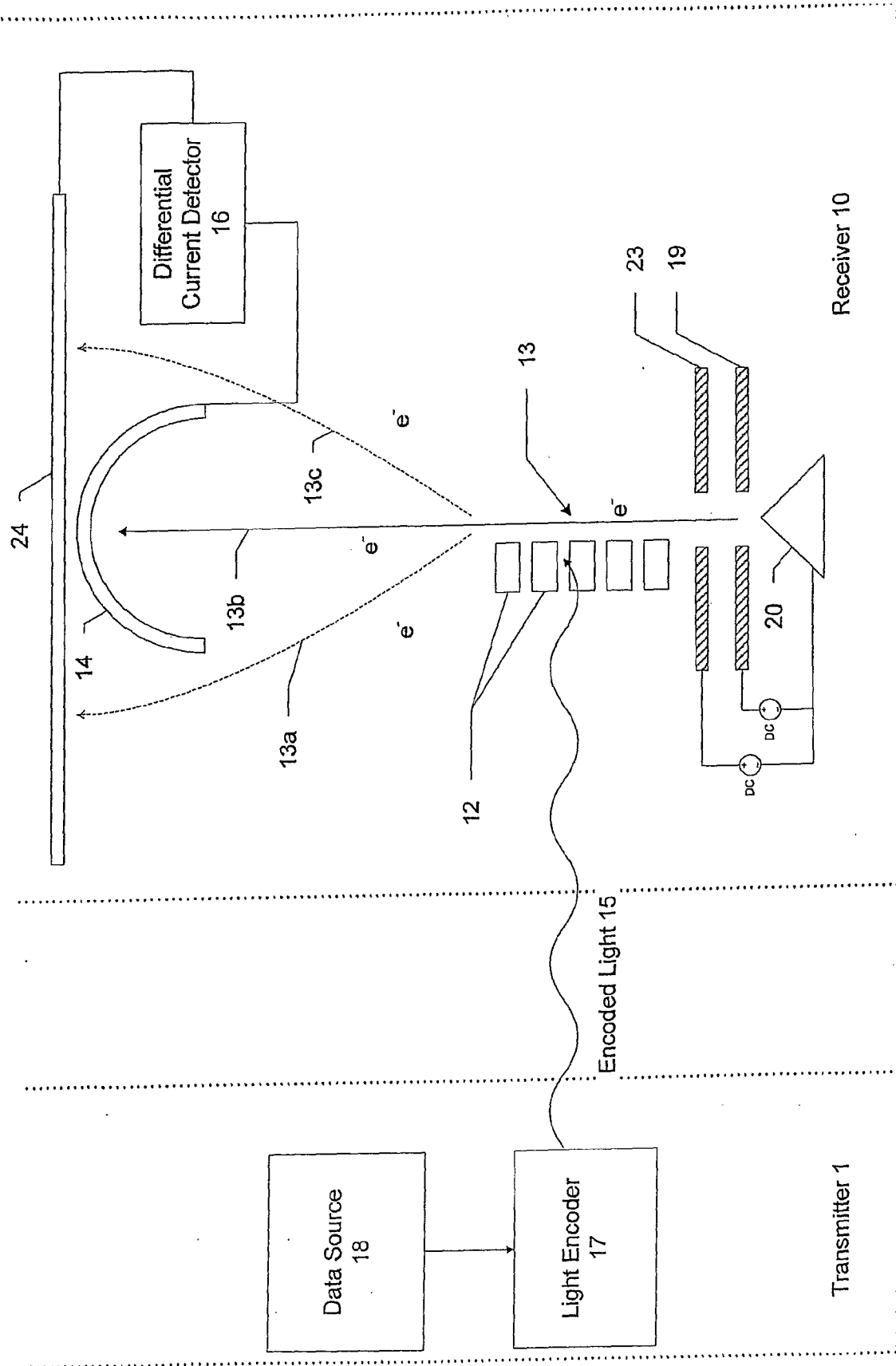


Figure 1

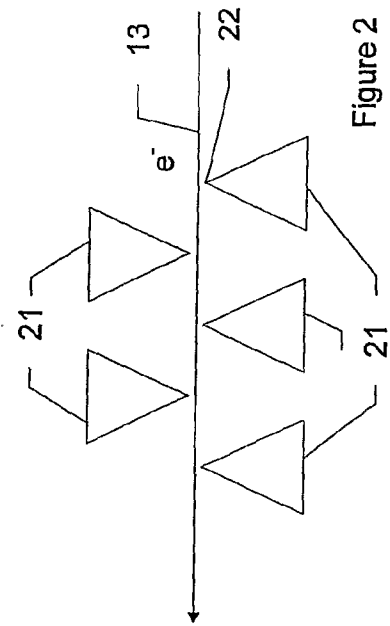


Figure 2

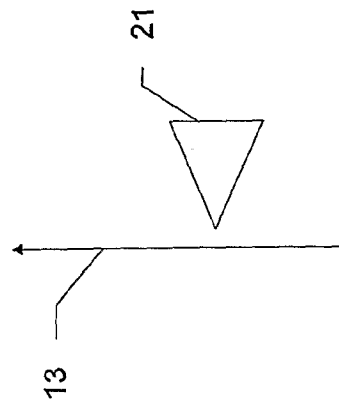


Figure 3

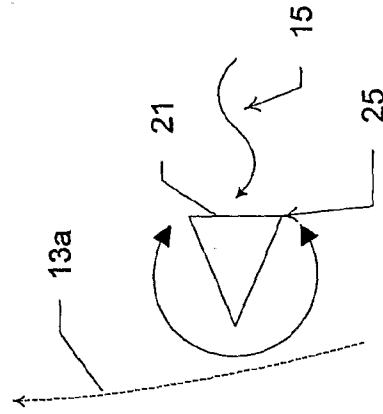


Figure 4

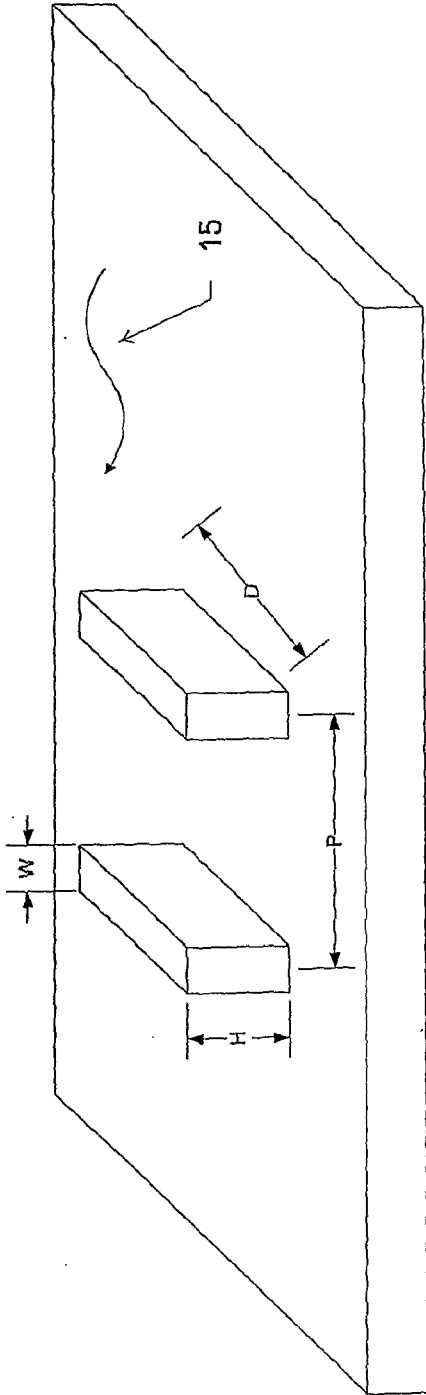


Figure 5

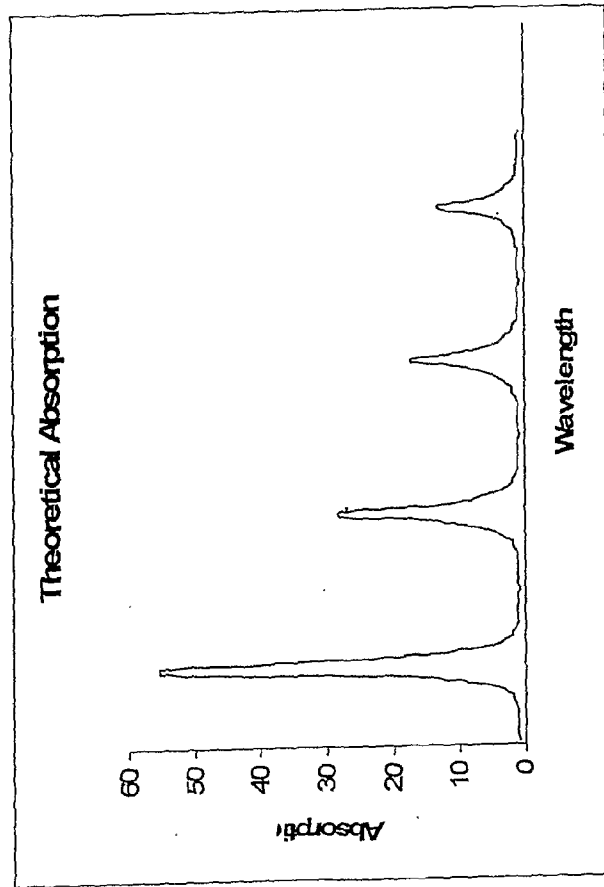


Figure 6

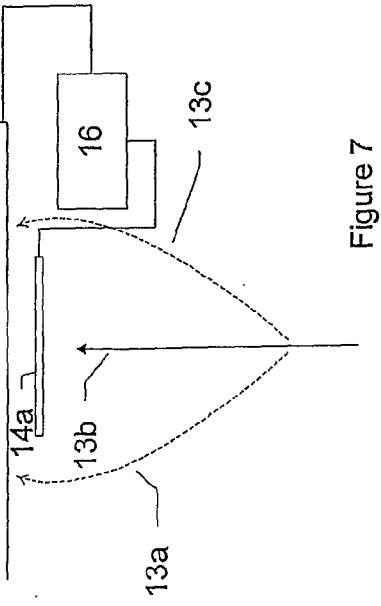


Figure 7

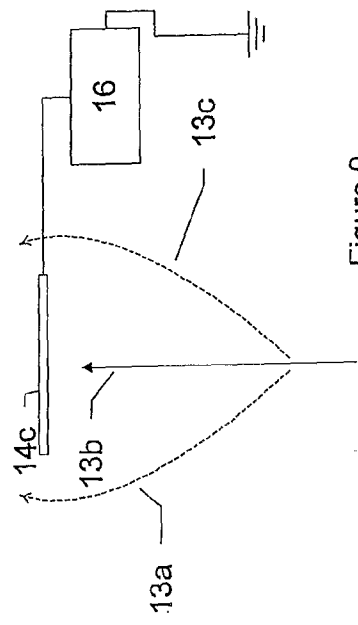


Figure 9

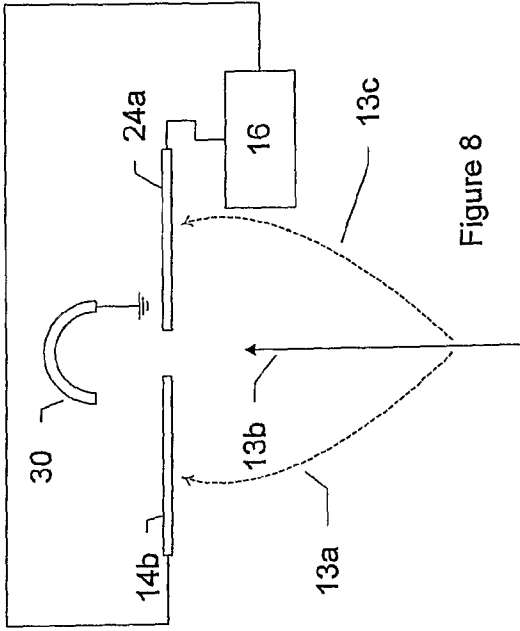


Figure 8

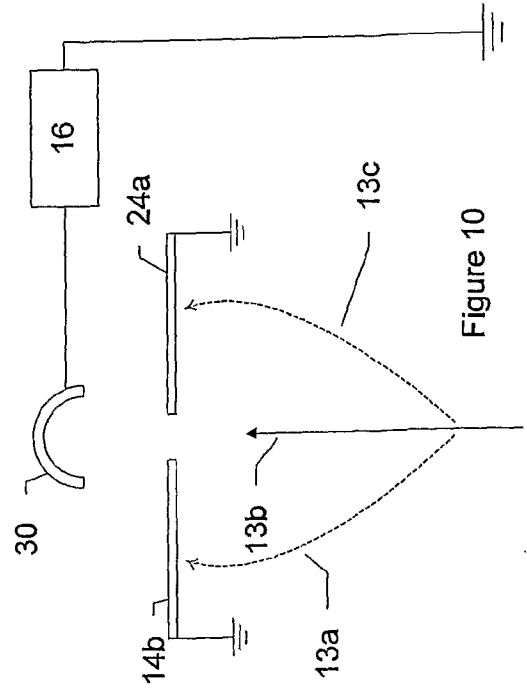


Figure 10

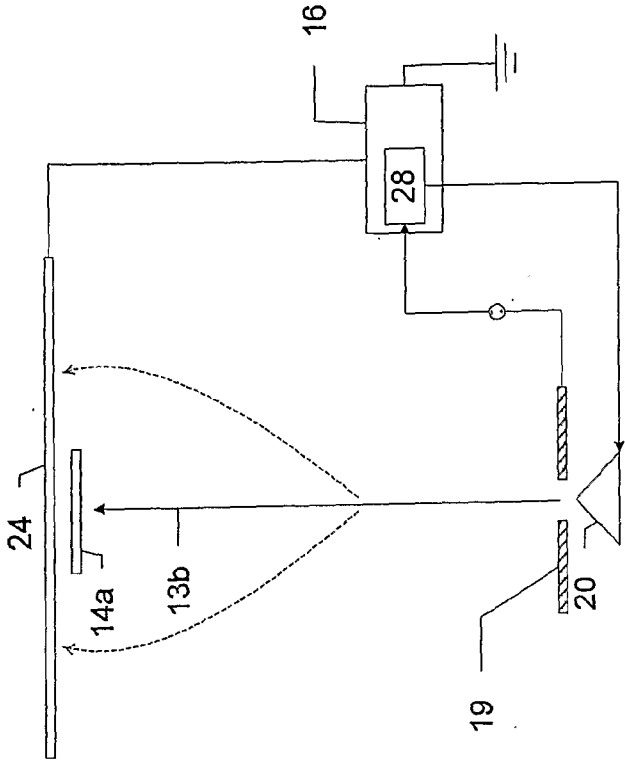


Figure 12

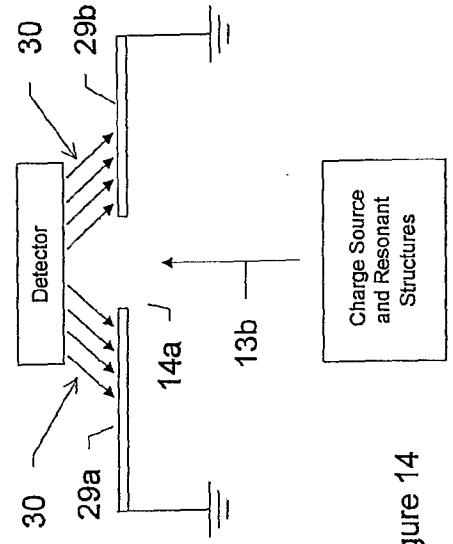


Figure 14

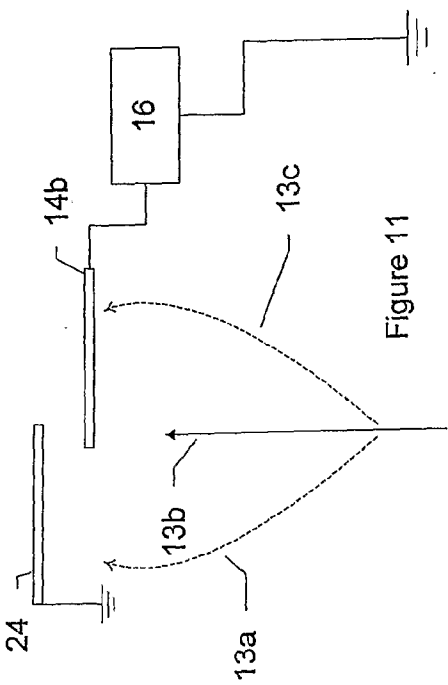


Figure 11

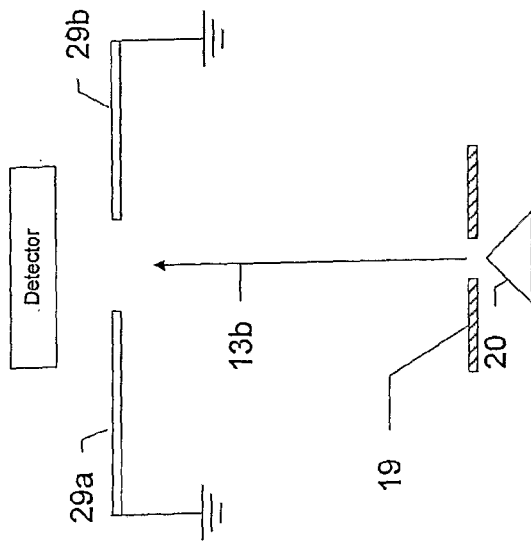


Figure 13

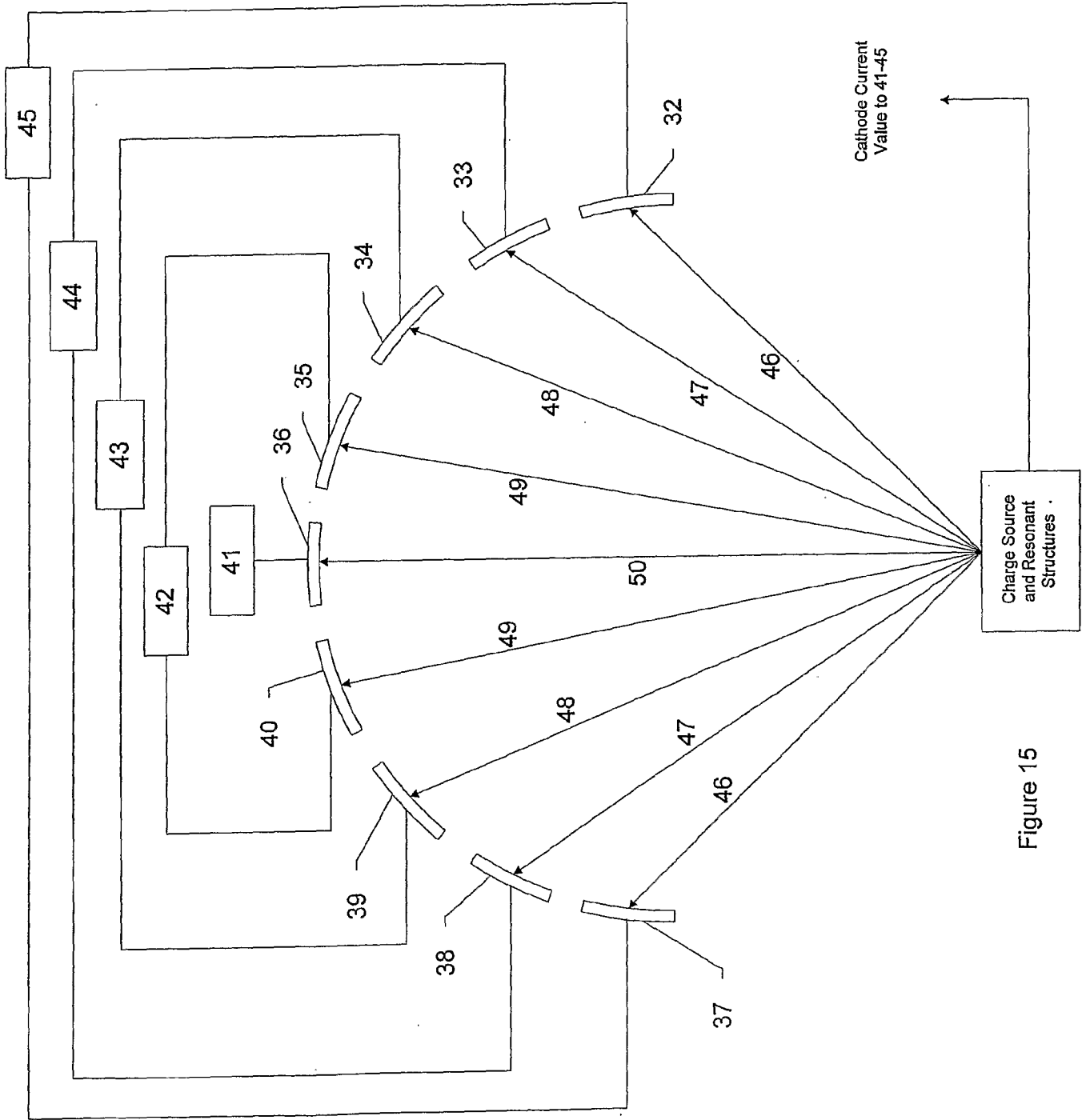


Figure 15

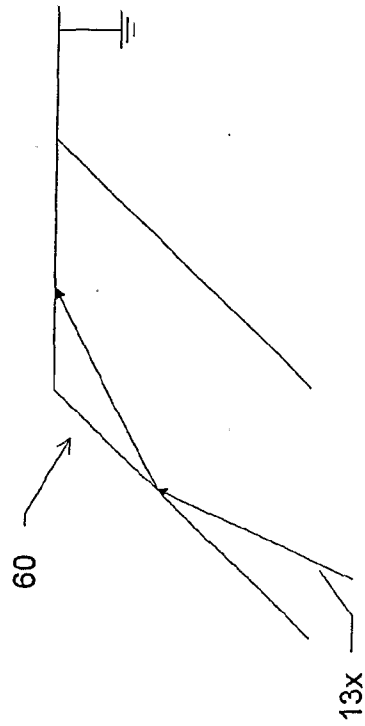


Figure 17

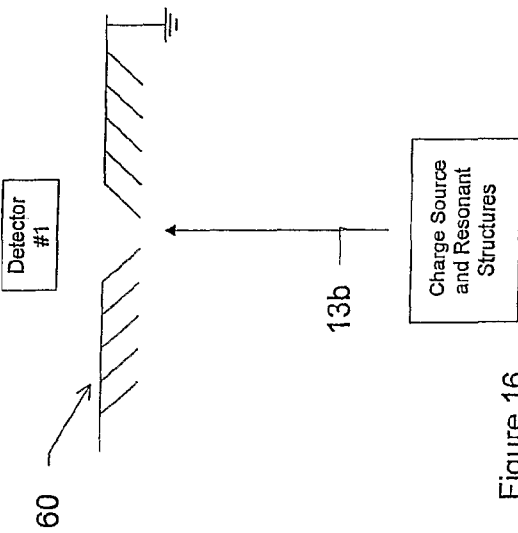


Figure 16

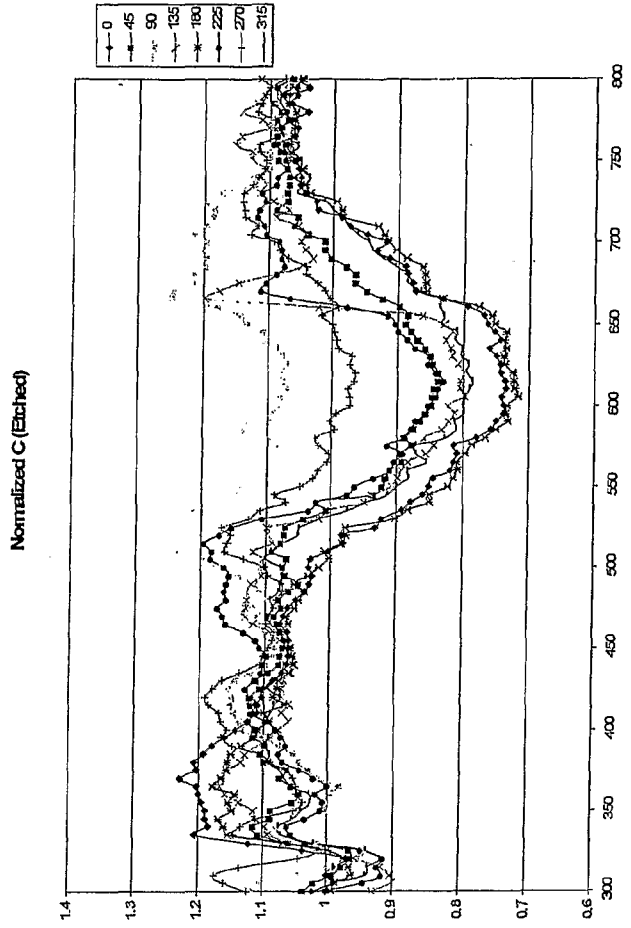


Figure 19

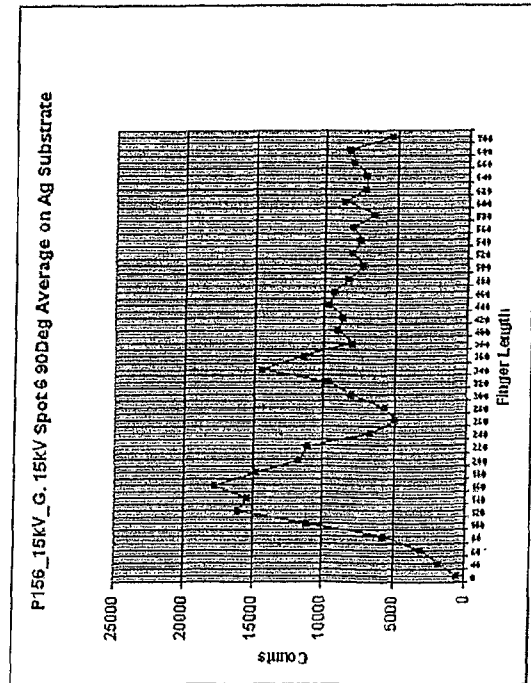


Figure 18

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 06/22680

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - A23G 9/34, A23G 9/46 (2007.01) USPC - 310/313R According to International Patent Classification (IPC) or to both national classification and IPC</p>														
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols) USPC - 310/313R</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC - 310/313R; 430/318 (keyword limited - see keywords below)</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WEST (USPT, PGPB, USOC, EPAB, JPAB Search Terms: ion, electron, beam, emitter, collector, deflector, surface plasmon resonance, lense, and nano</p>														
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>US 2005/0092929 A1 (Schneiker) 05 May 2005 (05.05.2005), entire document, especially para [0179]; and FIG. 24A.</td> <td>1-18</td> </tr> <tr> <td>Y</td> <td>US 2,431,396 A (Hansell, C.) 25 November 1947 (25.11.1947), entire document, especially, col 2, ln 46 to col 5, ln 20; and FIG. 1.</td> <td>1-18</td> </tr> <tr> <td>Y</td> <td>US 2003/0164947 A1 (Vaupel) 04 September 2003 (04.09.2003), entire document, especially at para [0073] and [0075]; and FIGs. 1-3.</td> <td>2-5, 10-12, and 14</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	US 2005/0092929 A1 (Schneiker) 05 May 2005 (05.05.2005), entire document, especially para [0179]; and FIG. 24A.	1-18	Y	US 2,431,396 A (Hansell, C.) 25 November 1947 (25.11.1947), entire document, especially, col 2, ln 46 to col 5, ln 20; and FIG. 1.	1-18	Y	US 2003/0164947 A1 (Vaupel) 04 September 2003 (04.09.2003), entire document, especially at para [0073] and [0075]; and FIGs. 1-3.	2-5, 10-12, and 14
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Y	US 2,431,396 A (Hansell, C.) 25 November 1947 (25.11.1947), entire document, especially, col 2, ln 46 to col 5, ln 20; and FIG. 1.	1-18												
Y	US 2003/0164947 A1 (Vaupel) 04 September 2003 (04.09.2003), entire document, especially at para [0073] and [0075]; and FIGs. 1-3.	2-5, 10-12, and 14												
<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/></p>														
<p>* Special categories of cited documents:</p> <table border="0"> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"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</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"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</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"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</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance	"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	"E" earlier application or patent but published on or after the international filing date	"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	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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	"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	"P" document published prior to the international filing date but later than the priority date claimed			
"A" document defining the general state of the art which is not considered to be of particular relevance	"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													
"E" earlier application or patent but published on or after the international filing date	"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													
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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													
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"P" document published prior to the international filing date but later than the priority date claimed														
<p>Date of the actual completion of the international search 23 June 2007 (23.06.2007)</p>		<p>Date of mailing of the international search report 31 AUG 2007</p>												
<p>Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201</p>		<p>Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774</p>												