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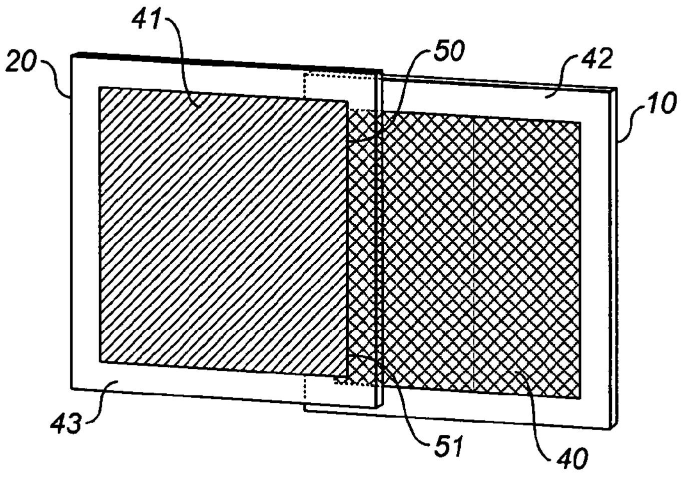
(54) Title: IMAGING SYSTEM WITH TILED SENSOR CHIPS HAVING PARTIALLY OVERLAPPING ACTIVE AREAS



(57) Abstract: The invention relates to imaging systems, in particular those comprising an array of imaging tiles. Existing systems suffer from areas of low-resolution in areas at the edges and between adjacent imaging tiles, due to the existence of inactive regions of tiles that are not capable of detecting incident radiation, causing a loss of information. In embodiments of the present invention, imaging tiles are arranged in a matrix form, a first of the imaging tiles 100 being arranged such that its active region 110 overlaps the active region 210 of a second of the imaging tiles 200, for enabling a portion of radiation incident to traverse a portion of the active region of the first imaging tile and to impinge on a portion of the active region of the second imaging tile. Thus, loss of information and consequent low resolution is avoided by arranging active regions to overlap.

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IMAGING SYSTEM WITH TILED SENSOR CHIPS HAVING PARTIALLY OVERLAPPING ACTIVE AREAS

Field of the Invention

The present invention relates to imaging, and in particular, though not limited to, X-ray and Gamma-ray radiation imaging.

Background of the Invention

Systems for high-resolution imaging have traditionally included wire chambers, scintillating crystals or screens and CR (computed radiography) screens. More recently, imaging systems have incorporated semiconductor technology therein and this has led to the development of well known devices such as charged coupled devices, silicon micro-strip detectors and semiconductor pixel detectors.

In view of its application to the medical sector, high-resolution imaging of X-rays has been of particular interest: many workers have expended a significant amount of effort in the development of suitable imaging systems, in particular focusing on improving resolution and overcoming practical problems associated with imaging over large areas. An example of an application of X-ray imaging systems is the field of clinical imaging, e.g. mammography. Currently, the most advanced clinical imaging systems have either a scanning detection system, which requires multiple exposures per projection, or a large flat system. The present invention relates to the latter type. Typically, large imaging areas may be formed either as a monolithic structure, or from a mosaic of smaller imaging tiles.

Large monolithic imaging surfaces suffer from low manufacturing yield, since, if any part of the imaging area is defective then the whole area must be replaced. Similarly, if any part is damaged during use, the whole of the expensive imaging surface needs to be changed.

Tiling approaches may use CMOS hybrid imaging tiles comprising a pixel array detector integrated with CMOS readout chips. Systems using imaging tiles mitigate the problem of low manufacture yield, since damage to one of the tiles necessitates only the replacement of the damaged tile. However, tiling arrangements suffer from poor spatial resolution in the regions at the edges of and between tiles, as described below.

Currently, it is possible to construct a single shot image with no discontinuities covering a surface of area of the order 6cm x 6cm. In recent years, there has been considerable interest in obtaining images over greater dimensions. However, a problem arises when arranging imaging systems in planar matrix form in that, when a large area is covered for the region of interest, a loss of spatial resolution arises due to the unavoidable presence of insensitive zones at the edges. This is illustrated in figure 1 where two imaging tiles 10 and 20 of a planar matrix imaging system 30 are arranged adjacent to each other at a certain distance “d” along an axis “X”. Each imaging tile 10, 20 has an active region 40, 41 equipped with sensitive pixels and a region without pixels 42, 43, ineffective for the detection of radiation.

Such a detection system allows the construction of an image corresponding to two physical zones A and B of a surface C. As can be seen, there is a dead zone D between A and B which will not contribute to the image, as it belongs to the inactive region of the two imaging tiles 10 and 20.

An attempt to mitigate this problem is depicted in figures 2A and 2B. Turning first to figure 2A, it can be seen that imaging tile 20 is arranged above imaging tile 10 in a manner such that the edge of their inactive regions 42, 43 overlap as much as possible (figure 2A). As a result, the distance between two active regions 40 and 41, and the width of the dead zone D along the X axis are reduced.

Ideally, the arrangement of the two imaging tiles 10 and 20 should, in a planar view, be such that the edges of the active regions are seamless. Such an arrangement is illustrated in the planar view of figure 2B. The active region 40 ends at an edge 50 which coincides with the edge 51 of the active region 41.

As a consequence, ideally there should be no gap between the two edges, and the dead zone D should disappear.

However, in practice, it is well known that this overlapping imaging tiles arrangement does not give a satisfactory answer to the problem of obtaining a seamless resolution of an image over the whole surface of the detection matrix because, in order to achieve this objective, the sensors are required to be assembled with very high accuracy, and this presents considerable practical difficulties. These difficulties inhibit the development of systems that satisfy requirements for increasingly higher resolution and consequent finer pixel pitch. In order to be useful, the accuracy of the assembly may need to be of the order of a few pixels along orthogonal axes X and Y.

Several solutions are known, which involve shifting every sensor or group independently, and in a precise manner, by placing them into different mechanical supports enabling movement along three directions in space. However these solutions are of limited usefulness when the pixel size is lowered to tens of microns and the mechanical alignment constraints of the systems become more and more stringent.

Another problem associated with this solution relates to the fabrication procedures of the pixel sensors; more specifically a certain number of pixels may malfunction due to errors in handling or fabrication. In particular it is well known that fabrication defects appear and have their most significant effects along the edges of the imaging tiles. As a result, even if an accurate mechanical alignment of the two sensors (for example 10 and 20 referring to figure 2B) could be achieved, a loss of resolution at the edges of the two regions, and most importantly in the overlapping region, is experienced. This problem could be addressed by rejecting and replacing defective tiles; however, the prevalence of defects results in an unacceptably high reject rate in this case.

Whilst the fabrication methods of the sensitive pixel zones can be improved, in view of the constraints of certain applications such as the clinical ones, which are very demanding in terms of response and of obtaining regulatory approval, this solution has not proved to be satisfactory in any real system in applications such as those of clinical imaging.

Another possible solution involves the use of software algorithms that provide full reconstruction, or at least improvement in terms of spatial resolution, of those portions of the images that correspond to "dead zones" D (for example one can use an interpolating algorithm). Whilst this technique is extensively used, it is unable to recover lost information, and therefore can, at best, only provide approximations; it does not therefore currently provide a satisfactory solution to the problem of dead zones, in particular for the abovementioned fields of application. This problem is particularly acute in cases such as those for which regulatory approval demands no, little, or only moderate use of non sophisticated algorithms for dead zones. In the example of mammography for example, a machine including a detection system with algorithms that recover insensitive zones may be rejected due to the presence of pathology markers that are smaller than the size of a dead region, because these regions may not be detected by a system using software interpolation.

An object of the present invention is to provide an imaging system that has a large imaging area with no discontinuities, and requires only a single exposure per projection, thereby overcoming the problem of the dead zones as described above.

Summary of the Invention

In accordance with one aspect of the present invention, there is provided an imaging system comprising a plurality of imaging tiles arranged in a matrix form, each imaging tile being mounted on a support, wherein each imaging tile comprises:

a surface comprising an array of pixels, said array of pixels defining an active region capable of detecting incident radiation; and

circuitry connected to the pixel matrix, said circuitry being adapted for reading and processing signals from the array of pixels, wherein

a first of the imaging tiles is arranged such that its active region overlaps the active region of a second of the imaging tiles, for enabling a portion of radiation incident on the imaging system to traverse a portion of the active region of the first imaging tile and to impinge on a portion of the active region of the second imaging tile.

Thereby the present invention mitigates the problem of loss of spatial resolution in the dead zone, in a way which is distinct from the prior art methods of improving the performances of algorithms or fabrication methods, by using double information originating in overlapping active regions. It can be appreciated that the information of one or more pixel lines of an imaging tile may be redundant in view of corresponding information from an overlapping imaging tile. As a result information can be selectively used during reconstruction of the image.

Furthermore, the present invention is not dependent on using software interpolation algorithms; image processing is used to reconstruct the image, but, unlike conventional systems, it is not needed as the sole way to compensate for dead zones. This aspect of the invention solves the problem of the regulatory requirements mentioned above.

In a preferred embodiment of the invention, the first imaging tile is laterally offset with respect to the second imaging tile. This allows an imaging surface extending over a large area to be formed, while maintaining the advantageous double information enabled by the invention. The tiles may be arranged such that an overlapping edge of the first tile is substantially parallel to an edge of the second tile. This allows the tiles to be arranged in a regular pattern, facilitating the formation of an image surface.

In another preferred embodiment of the invention, the imaging system comprises a set of imaging tiles, the set comprising a group of imaging tiles in which the active region of a given imaging tile in the group is overlapped by, and laterally offset with respect to, a preceding imaging tile in the group, for enabling a portion of radiation incident upon the imaging system to traverse a portion of the active region of said preceding tile and to impinge on a portion of the active region of the given tile. This enables a staircase configuration, which is a convenient way of arranging tiles so that each tile overlaps another (with the exception of the tile located at one extremity of the staircase).

The aforementioned set may comprise a further group, in which the active region of a given imaging tile in the further group is overlapped by, and laterally offset with respect to, a succeeding imaging tile in the further group, for enabling a portion of radiation incident upon the imaging system to traverse a portion of the active region of said succeeding tile and to impinge on a portion of the active region of said given tile of said further group. The group and the further group may have at least one imaging tile in common. This enables an "ascending" staircase configuration to be joined to a "descending" staircase configuration, which avoids the thickness of the tiling arrangement being excessive. This may be further facilitated by arranging the set so that the number of imaging tiles in the further group is the same as the number of imaging in the first group.

The thickness of the tiling arrangement may be further reduced by arranging a periodic sequence of imaging tiles, said periodic sequence comprising a plurality of said imaging tile sets. In some embodiments, each of said imaging tile sets has at least one imaging tile common with another set, thereby generating a series of alternating ascending and descending staircase configurations.

Further, individual tiles within the sets may be periodically spaced along orthogonal axes. Alternatively, or additionally, individual tiles within a given set may be disposed in a substantially parallel configuration with respect to individual tiles of another set. These features facilitate the formation of a large imaging area extending in two dimensions. At least some of the individual tiles within a given set may be disposed so as to overlap individual tiles of another set. This facilitates the formation of large imaging areas without dead zones.

In a still further embodiment, the first imaging tile abuts a further imaging tile such that there is no overlap between respective active regions of the first and further imaging tiles. In some applications, the improved resolution that is a benefit of overlapping active regions may not be required over the whole imaging surface.

The imaging tiles may comprise semiconductor radiation tiles. They may be formed from a material that is an alloy of at least one of Silicon, Gallium, Tellurium, Cadmium, Zinc, Indium and Arsenic.

Each imaging tile may comprise a sensor and an integrated circuit connected to said sensor. Said sensor and said integrated circuit may be integrated into the same substrate. This avoids the thickness of the imaging tiles being too great.

The imaging tiles may be manufactured using CMOS hybrid technology.

In advantageous embodiments, the support comprises means for selectively adjusting the position of an imaging tile mounted thereon. This allows the alignment of imaging tiles to be fine tuned.

In some embodiments, each support may have substantially the same dimensions. This decreases the manufacturing costs of the system.

In accordance with another aspect of the invention, there is provided a method of manufacturing an imaging device comprising a plurality of imaging tiles, each imaging tile comprising an array of pixels, said array of pixels defining an active region capable of detecting incident radiation, and circuitry adapted for reading and processing signals from the array of pixels, the method comprising:

mounting each of said imaging tiles to a support; and

mechanically connecting each support to a substrate, such that an active region of a first of the imaging tiles overlaps the active region of a second of the imaging tiles, for enabling a portion of radiation incident on the imaging system to traverse a portion of the active region of the first imaging tile and to impinge on a portion of the active region of the second imaging tile.

The method may further comprise fixing an imaging tile to an imaging tile base and mounting said imaging tile base to said support. Further, the position of the tile base can be adjusted. This facilitates correct alignment of the imaging tiles.

In preferred embodiments, the method may further comprise:

using said imaging device to capture an image;

reviewing said captured image so as to detect any defective imaging tiles; and

replacing defective imaging tiles on the basis of said review.

Thus, defective imaging tiles can be detected and replaced during the manufacturing process, increasing manufacturing yield and the precision of the imaging system.

In further preferred embodiments, the method may further comprise:

using said imaging device to capture an image;

reviewing said captured image so as to identify the alignment of said first imaging tile with respect to said second imaging tile; and

adjusting said alignment on the basis of the review.

The alignment of overlapping imaging tiles may thereby be fine tuned during the manufacturing process; this improves the precision of the imaging system.

Alternatively, or additionally, the method may include comparing incident radiation detected by the first imaging tile with incident radiation detected by the second imaging tile, so as to perform said adjustment. Said comparison may comprise comparing the position of an identifiable feature of said image as detected by the first imaging tile with the position of said identifiable feature as detected by the second imaging tile. Further, a required alignment may be identified and said mounting means adjusted on the basis of the required alignment. These features allow a required alignment to be obtained without using external measurement devices.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a perspective view of the two imaging tiles arranged adjacently as in the prior art;

Figure 2A is a perspective view of two imaging tiles where one overlaps the other as in the prior art;

Figure 2B is a planar view of the two imaging tiles of figure 2A (prior art)

Figure 3 is a perspective view of a matrix using two imaging tiles arranged according to an embodiment of the present invention;

Figure 4 is a sliced view of four imaging tiles arranged according to an embodiment of the present invention;

Figure 5 is a perspective view from above a portion of the imaging tile matrix shown in figure 4;

Figure 6 is a sliced view of an imaging tile arrangement having a staircase-configuration;

Figure 7 is a side view of a mechanical support for supporting tiles in accordance with an embodiment of the present invention;

Figure 8 shows an expanded view of two imaging tiles according to an embodiment of the present invention;

Figure 9 shows a portion of an example of the detection system of an embodiment of the present invention mounted into a support;

Figure 10 shows the image that is obtained with an imaging system including and according to an embodiment of the present invention;

Figure 11 is an image corresponding to the result of figure 9 improved by a simple image software treatment.

In the accompanying figures, those parts and steps that are common between embodiments are allocated the same reference number, whilst those that are particular to a specific embodiment are allocated a distinct reference number.

Detailed Description of the Invention

Embodiments of the invention provide imaging systems having a large, continuous imaging surface free from dead zones and other problems incumbent in the prior art. Specific examples are now described. Turning to figure 3, an embodiment of the invention, hereinafter referred to as tiling arrangement 1, will be disclosed in relation to two imaging tiles 100, 200. In one arrangement, each imaging tile 100, 200 is made out of a substrate of semiconductor material comprising a region sensitive to radiation or active region 110, 210 therein, embodied as a plurality of pixels; around the active region 110, 210 there is an inactive region 120, 220 which does not comprise any pixels. The two imaging tiles 100 and 200 are arranged such that a portion of the active region 110 of the imaging tile 100 overlaps a portion of the active region 210 of the imaging tile 200. This overlapping portion is indicated in figure 3 as the region R.

In a preferred embodiment the active region overlapping portion R defines a zone in which the number of pixels is small compared to the total number of pixels in the active region. For example, with reference to the orthogonal axis X and Y of figure 3, portion R comprises of the order of 3 to 5 pixel lines among more than two hundred pixel lines in the X direction. The dimensions of this overlapping portion may be altered on a case by case basis, depending on the application and function of the tiling in question. In relation to overlap in the Y direction, portion R preferably extends along an entire edge of the active regions 110 and 220.

In one arrangement, the tiling arrangement 1 comprises a set of imaging tiles, and individual tiles within the set are arranged such that the active region of each imaging tile in the set overlaps and/or is overlapped by, and offset with respect to an adjacent imaging tile in the set; in this way a detection matrix is formed from a staircase-shaped arrangement of a set of partially overlapping tiles. An example of a staircase-shaped arrangement 400, 401 in accordance with embodiments of the present invention, is represented in figure 4. Sets of imaging tiles 400, 401 arranged in staircase-configuration may be arranged to overlap, as shown in figure 5. It is easy to see how this arrangement of overlapping sets of overlapping tiles could be expanded to cover a large area.

A further example is shown in figure 6. In this tiling arrangement 1, imaging tiles are arranged in a periodic sequence of successively offset tiles, the active region of each tile overlying the active region of an adjacent tile (with the exception of the tile located at one extremity of the staircase); the periodic sequence comprises a plurality of sets of imaging tiles (500, 400, 503), each set forming a staircase-shape. Sets 500 and 502, which are parallel to line 1 and arranged in an ascending staircase configuration when viewed left to right, are interspersed by set 400 which is parallel to line 2 and arranged in a descending staircase configuration when viewed from left to right; repeating sequences of this type can be employed to ensure that the thickness of the device is not too great. The number of imaging tiles comprising each set can be varied according to requirements.

Figure 7 is a schematic side view of an example embodiment of a mechanical support arrangement that may be used or adapted to support tile arrangements 1 as described above. Rigid supports 560, 561, 562 are mechanically connected to a rigid substrate 550, said substrate being staircase-shaped in order to facilitate positioning of the arrangement according to embodiments of the invention. The mechanical connection may comprise a screw and thread arrangement (not shown).

Imaging tiles 100, 200, 700 are affixed to rigid bases 570, 571, 572; typically this fixing may be achieved using an adhesive. Each of the bases 570, 571, 572 is mechanically connected to a support 560, 561, 562 and positioned so that respective active regions 110, 210, 310 of the imaging tiles 100, 200, 700 overlap. In preferred embodiments, the means of mechanical connection between the bases 570, 571, 572 and the supports 560, 561, 562 should allow adjustment of the extent of overlap according to requirements. For example, a screw and thread means could be employed whereby the lateral position of the base may be altered by a known distance for every revolution of the screw.

The semiconductor substrates used in some embodiments of the present invention have a thickness and/or a density chosen to obtain an advantageous combination of transparency and absorption efficiency. Transparency here refers to the propensity of a substrate to allow, for example, although not limited to, X-ray radiation to pass through said substrate without interacting, or only partially interacting, with it. The complementary property to this is absorption, which indicates the ability of the semiconductor substrate material to interact with the impinging radiation. The absorption has a directly proportional relationship with the detection efficiency, while transparency has an inversely proportional relationship with the detection efficiency. It follows that higher absorption leads to higher sensitivity of the imaging tile. This aspect is of great relevance to applications such as radiology with X-rays.

An advantageous aspect of embodiments of the present invention is that the incident radiation flux traverses at least two portions of two respective active regions; this allows, for example, redundant information, avoiding information loss due to ineffective pixels. The characteristics of the components are therefore chosen to obtain the required compromise between sensitivity (absorption) and the ability to allow incident radiation to traverse the imaging tiles (transparency).

An arrangement capable of achieving this balance is illustrated in figure 8, which shows an enlarged view of first and second imaging tiles 600 and 601 arranged according to an embodiment of the present invention. After a primary radiation flux 602 is emitted from a radiation source E1, it traverses the first imaging tile 100 which absorbs part of the photons and detects these in its active region. The radiation exits the imaging tile as secondary radiation 603 having the same nature as the primary radiation 602, but with a reduced flux or intensity, the amount of the reduction depending essentially on the transparency and absorption characteristics of the semiconductor material. The secondary radiation 603 then encounters second imaging tile 200, or, more precisely, the secondary radiation 603 impinges on one or more detection pixels in the active zone of the portion R of the second imaging tile 200, said detection pixels then detecting the presence of the secondary impinging radiation 603, according to its intensity and to the material absorption (transparency) characteristics.

From the foregoing it will be appreciated that high transparency of the first imaging tile 100 is advantageous in allowing the second imaging tile 200 to detect sufficient photons of the secondary radiation 603, and that high absorption is advantageous in allowing the imaging tiles 100, 200 to detect sufficient numbers of photons of the primary and secondary radiation fluxes 602, 603 respectively.

Whilst the first and second imaging tiles shown in figure 3 and figure 8 comprise semiconductor material having the same nature or thickness, it will be appreciated that individual tiles of the tiling arrangement 1 can have different detection properties and geometric configurations, and that the performance of detection systems according to the present invention can be optimized by tuning the thickness and material of the substrate forming individual imaging tiles.

In relation to substrate selection, a thin high-density material can have the same absorption and transparency properties as a thick low-density material, but different electrical properties such as charge diffusion and dispersion inside the substrate. Such electrical properties may be decisive in final material selection. Other properties that may influence final choice of material type and thickness include the energy and intensity of the beam, and the type of object under examination etc.

Properties of an example tiling arrangement 1 for use in full field digital X-ray mammography will now be described.

Thickness: approximately 500 micrometers;

Material: high resistivity radiation detection grade silicon;

Absorption ($E \approx$ 10-20 kev) : 10-40 %

Pixel size: approximately 50 microns;

Overlap: approximately 3 pixel lines overlapping;

Columns per line: approximately 250 pixel columns (X direction) per line;

Pixels per column: approximately 250 pixels per column (Y direction)

Additional Details

Imaging tiles may comprise a matrix of pixels forming a sensor and further comprise integrated electronics arranged to read and process signals from the sensor. An example imaging tile may comprise 128x128 pixels of 50 microns width which may be read by a unique integrated electronic circuit.

Preferably, the sensor and read out circuitry are integrated so as to simplify the connections and save space, therefore improving processing speed and quality. For example, an Application Specific Integrated Circuit (ASIC) fabricated using CMOS or similar material may be used.

Further, in order for the ASIC to be located as close as possible to the sensor, they may be connected by micro bonding, soldering or gluing. An even higher level of integration may be achieved by integrating the sensor and the ASIC into the same semiconductor substrate.

In one arrangement, the integrated electronic circuit is capable of reading out analogue signals and may convert these to digital signals. In certain embodiments each pixel may have its own independent processing logic and circuitry, each pixel delivering an independent signal. In order to reduce complexity and requirement for physical space, the signals may be routed to one edge of the inactive region of the imaging tile, either in analogue or digital form. Signal processing may be used in relation to grouping, setting thresholds and ordering the pixel matrix signal for subsequent treatment. The ASIC may deliver or embed directly a pre-treatment to facilitate recovery of the correct matrix ordering during post processing, taking into account the overlapping pixels.

The above described examples of processing may be implemented in the ASIC, using peripheral electronics or offline analysis, or any combination of these. The selection will depend on many considerations such as application, cost, speed etc.

Turning now to Figure 9, an example of how an embodiment of the present invention may be implemented in a detection system S is illustrated. Current technology suggests that best performance and cost effectiveness is achieved by having more than one ASIC connected to different portions of the same sensor part. In this case, system S uses sensors 800, 802, each associated to four ASICs 900...903, and cooled during operation by means of liquid circulating lines 1001, 1002. The system S comprises transition regions T1, T2, T3, corresponding to regions of coarser pitch at the edges of each ASIC and resulting from the dead regions of the ASICs themselves. Treatment of these transition regions is explained below, with reference to figures 9 and 10. Only a small number of pixel columns may be affected; for example, three pixel pitches for a total width of 150 micrometers for each transition region T1, T2, T3.

With reference to figure 10, an explanation is now given of how an image can be obtained with a system as disclosed in the present invention, without offline post processing.

Test conditions for obtaining an image may include the following:
Beam energy: approximately 70 KeV X-rays;
Thickness: approximately 500 micrometers;
Material: high resistivity detector grade Silicon;
Pixel size: approximately 50 microns;
Overlapping: approximately 5 pixel lines overlapping;
Pixels per line: approximately 128 pixels per line (X direction);
Pixels per column: approximately 128 pixels per column (Y direction)
ASIC substrate material: Silicon
Imaging tile size approximately (X) 6cm x (Y) 1,5cm
Distance to the source: approximately 50cm
Collimated beam

Only a portion of the image obtained by the imaging system is illustrated in figure 10. This portion corresponds to two imaging tiles S_A and S_B arranged according to the present invention and comprises three transition zones per imaging tile: T_1, T_2, T_3 and T_4, T_5, T_6 that demarcate areas S_1, S_2, S_3, S_4 and S_5, S_6, S_7, S_8 respectively. These transition zones correspond to the boundary areas between the ASICs of the imaging system described above with reference to figure 9.

There is a further transition region T_7 present, corresponding to the area of overlap of the tiles S_A and S_B. This region has a different intensity, often higher than the non overlapping regions. This is due to the double information coming from the two imaging tiles S_A and S_B. More precisely, in this region there is a contribution to the image from a first series of pixels on S_A and a second contribution from a second, overlapping, series of pixels on S_B, superimposed on the first contribution.

An example of a corresponding image obtained after simple image processing is shown in figure 11. A substantially homogenous image is obtained.

Sensor and ASIC substrates, geometry, mechanical arrangements and materials e.g. Gallium, Arsenic, Cadmium, Tellurium, Zinc, Indium etc. different to those described herein may be used in substitute for those described without deviating from the subject matter of the invention.

An example method of manufacturing such an imaging device will now be described, with reference to figure 7 and figure 9. In this example, it is assumed that imaging tiles 100, 200, 700 are glued to respective bases 570, 571, 572, but the skilled person will appreciate that alternative fixing methods are possible. Flexible cables for communicating signals are connected to the imaging tiles and the bases 570, 571, 572 are mounted on supports 560, 561, 562 in a manner such that the position of each tile-base arrangement may be easily adjusted, for example using a screw and thread (not shown). In this arrangement, the supports are rigidly fixed to the substrate 550 using screw and thread combinations (not shown). In some arrangements, the stability of the supports may be further increased by fixing individual supports to adjacent supports using long screws. Cooling pipes 1001, 1002 are fitted to the supports and connected to peripheral distribution tubes (not shown).

Since the inclusion of overlapping tiles leads to a duplicate of information in relation to a given aspect of the source E1 of the incident radiation, the alignment of the tiles may require adjustment, in order to ensure that the image is consistently reconstructed. This may be done by taking a test image, analyzing identifiable features of the test image to detect any tiles that require positional adjustment, and adjusting the position accordingly. For example, areas of the image having blurred or distorted features may indicate imaging tile misalignment. The tiles may then be repositioned by, for example, adjusting precision dowel pins or screws. This process can be repeated until satisfactory alignment is achieved. Further, the test image may be analyzed to detect any defective tiles which might result in, for example, blank regions occurring, and these defective tiles replaced.

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. For example, imaging tiles with overlapping active areas may be used in combination with prior art imaging systems, for example those that use software interpolation or scanning techniques. Also, instead of using supports that are removably connected to a substrate, in some applications the supports may themselves comprise a rigid substrate. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

Claims

1. An imaging system comprising a plurality of imaging tiles (100, 200, 300, 700) arranged in a matrix form, each imaging tile being mounted on a support (560, 561, 562), wherein each imaging tile comprises:

a surface comprising an array of pixels, said array of pixels defining an active region (110, 210) capable of detecting incident radiation; and

circuitry (900...903) connected to the pixel matrix, said circuitry being adapted for reading and processing signals from the array of pixels,

wherein a first of the imaging tiles (100) is arranged such that its active region (110) overlaps the active region (210) of a second of the imaging tiles (200), for enabling a portion of radiation incident on the imaging system to traverse a portion of the active region of the first imaging tile and to impinge on a portion of the active region of the second imaging tile.

2. An imaging system according to claim 1, wherein the first imaging tile (100) is laterally offset with respect to the second imaging tile (200).

3. An imaging system according to claim 1 or 2, wherein an overlapping edge of the first tile (100) is substantially parallel to an edge of the second tile (200).

4. An imaging system according to any preceding claim comprising a set of imaging tiles, the set comprising a group of imaging tiles (400) in which the active region of a given imaging tile in the group is overlapped by, and laterally offset with respect to, a preceding imaging tile in the group, for enabling a portion of radiation incident upon the imaging system to traverse a portion of the active region of said preceding tile and to impinge on a portion of the active region of the given tile.

5. An imaging system according to claim 4, wherein the set comprises a further group (500, 502), in which the active region of a given imaging tile in the further group is overlapped by, and laterally offset with respect to, a succeeding imaging tile in the further group, for enabling a portion of radiation incident upon the imaging system to traverse a portion of the active region of said succeeding tile and to impinge on a portion of the active region of said given tile of said further group.

6. An imaging system according to claim 5, wherein the group (400) and the further group (500, 502) have at least one imaging tile in common.

7. An imaging system according to claim 5 or claim 6, wherein the number of imaging tiles in the further group (500, 502) is the same as the number of imaging tiles in the group (400).

8. An imaging system according to any of claim 5 to claim 7, comprising a periodic sequence of imaging tiles, said periodic sequence comprising a plurality of said sets of imaging tiles.

9. An imaging system according to claim 8, wherein each set of imaging tiles has at least one imaging tile common with another set of imaging tiles.

10. An imaging system according to claim 8 or claim 9, wherein individual tiles within the sets are periodically spaced along orthogonal axes.

11. An imaging system according to any of claim 8 to claim 10, wherein individual tiles within a given set (401) are disposed in a substantially parallel configuration with respect to individual tiles of another set (400).

12. An imaging system according to claim 10 or claim 11, wherein at least some of the individual tiles within a given set (401) are disposed so as to overlap individual tiles of another set (400).

13. An imaging system according to any preceding claim, wherein the first imaging tile (100) abuts a further imaging (300) tile such that there is no overlap between respective active regions of the first and further imaging tile.

14. An imaging system according to any preceding claim, wherein the imaging tiles comprise semiconductor radiation imaging tiles.

15. An imaging system according to any previous claim, wherein the imaging tiles comprise a material that is an alloy of at least one of Silicon, Gallium, Tellurium, Cadmium, Zinc, Indium and Arsenic.

16. An imaging system according to any preceding claim, wherein each imaging tile comprises a sensor (800, 802) and an integrated circuit (900…903) connected to said sensor.

17. An imaging system according to claim 16, wherein said sensor (800, 802) and said integrated circuit (900…903) are integrated within the same substrate.

18. An imaging system according to any previous claim, wherein the imaging tiles are manufactured using CMOS technology.

19. An imaging system according to any previous claim, wherein the support (560, 561, 562) comprises means for selectively adjusting the position of an imaging tile (100, 200, 700) mounted thereon.

20. A method of manufacturing an imaging device comprising a plurality of imaging tiles (100, 200, 300, 700), each imaging tile comprising an array of pixels, said array of pixels defining an active region (110, 210) capable of detecting incident radiation, and circuitry adapted for reading and processing signals from the array of pixels, the method comprising:

mounting each of said imaging tiles to a support (560, 561, 562); and

mechanically connecting each support to a substrate (550), such that an active region (110) of a first of the imaging tiles (100) overlaps the active region (210) of a second of the imaging tiles (200), for enabling a portion of radiation incident on the imaging system to traverse a portion of the active region of the first imaging tile and to impinge on a portion of the active region of the second imaging tile.

21. A method according to claim 20, including fixing an imaging tile (100, 200, 700) to an imaging tile base (570, 571, 572) and mounting said imaging tile base to said support (560, 561, 562).

22. A method according to claim 21 including adjusting the position of the tile base (570, 571, 572).

23. A method according to any of claim 20 to claim 22, further comprising:

using said imaging device to capture an image;

reviewing said captured image so as to detect any defective imaging tiles; and

replacing defective imaging tiles on the basis of said review.

24. A method according to any of claim 20 to claim 23, further comprising:

using said imaging device to capture an image;

reviewing said captured image so as to identify the alignment of said first imaging tile (100) with respect to said second imaging tile (200); and

adjusting said alignment on the basis of the review.

25. A method according to claim 24, including comparing incident radiation detected by the first imaging tile (100) with incident radiation detected by the second imaging tile (200), so as to perform said adjustment.

26. A method according to claim 25, wherein said comparison comprises comparing the position of an identifiable feature of said image as detected by the first imaging tile (100) with the position of said identifiable feature as detected by the second imaging tile (200).

27. A method according to any of claim 24 to claim 26, comprising identifying a required alignment and adjusting said mounting means on the basis of the required alignment.

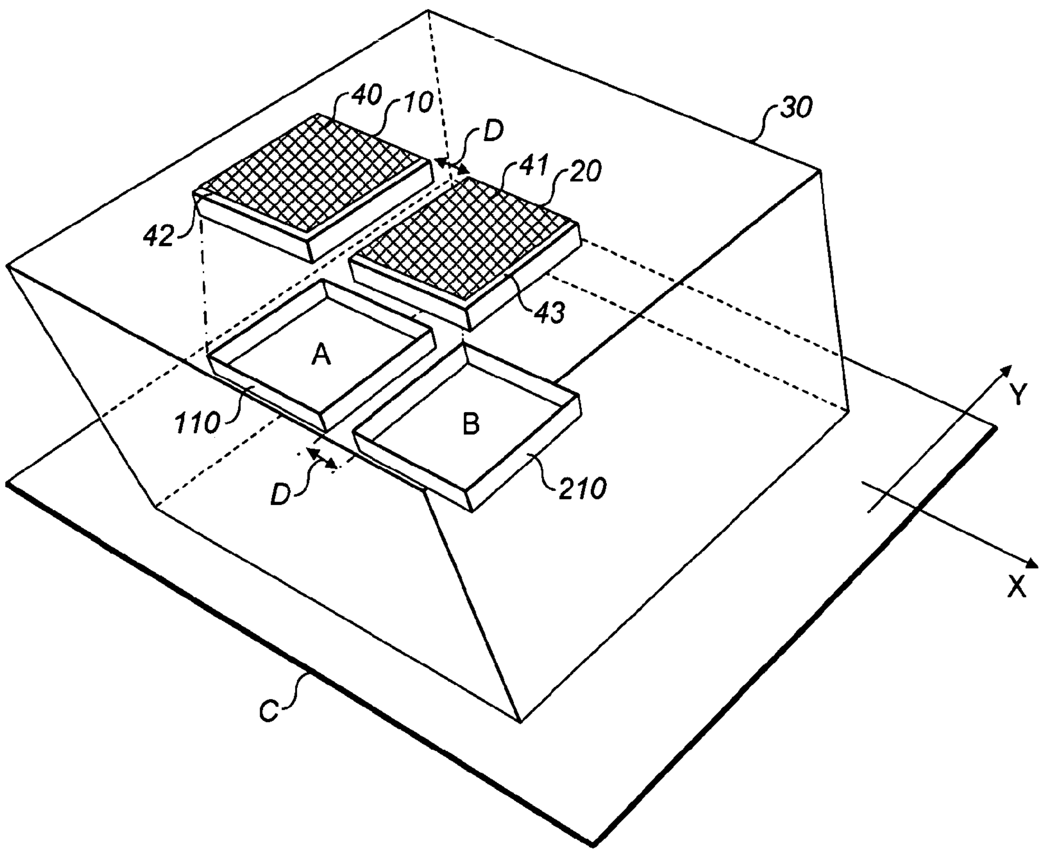


FIG. 1

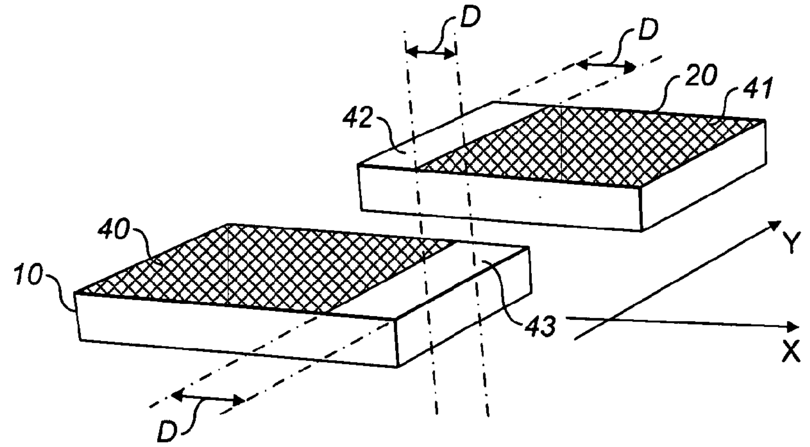


FIG. 2A

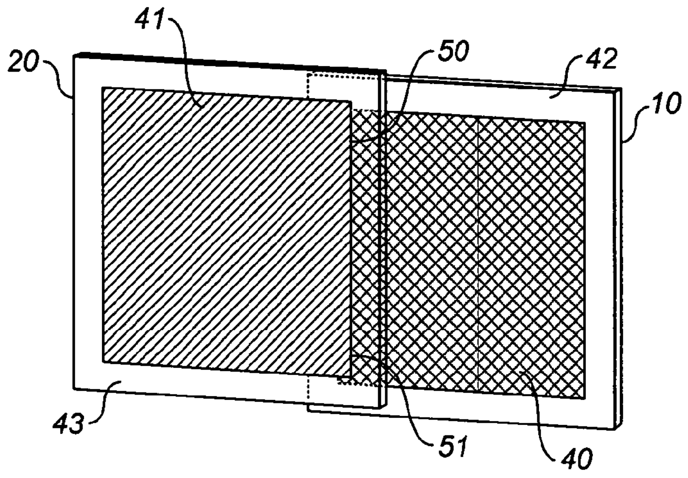


FIG. 2B

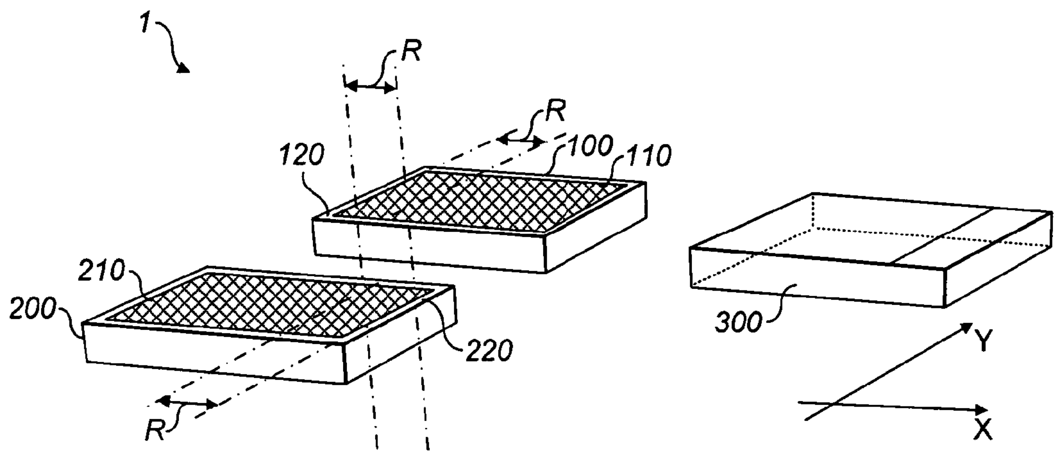


FIG. 3

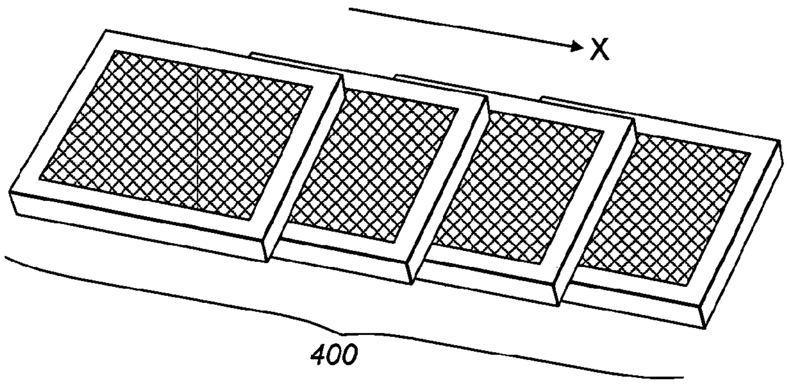


FIG. 4

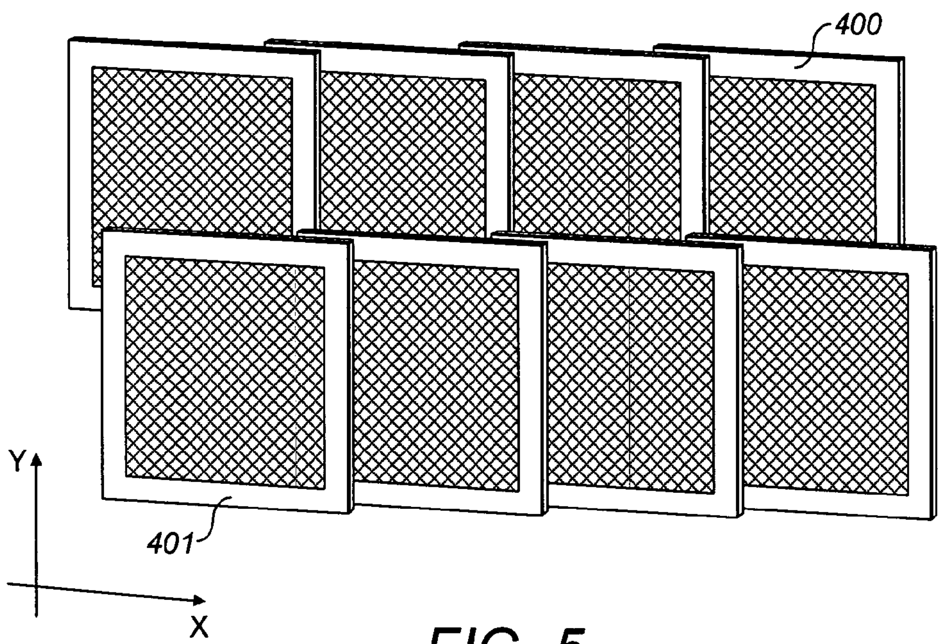


FIG. 5

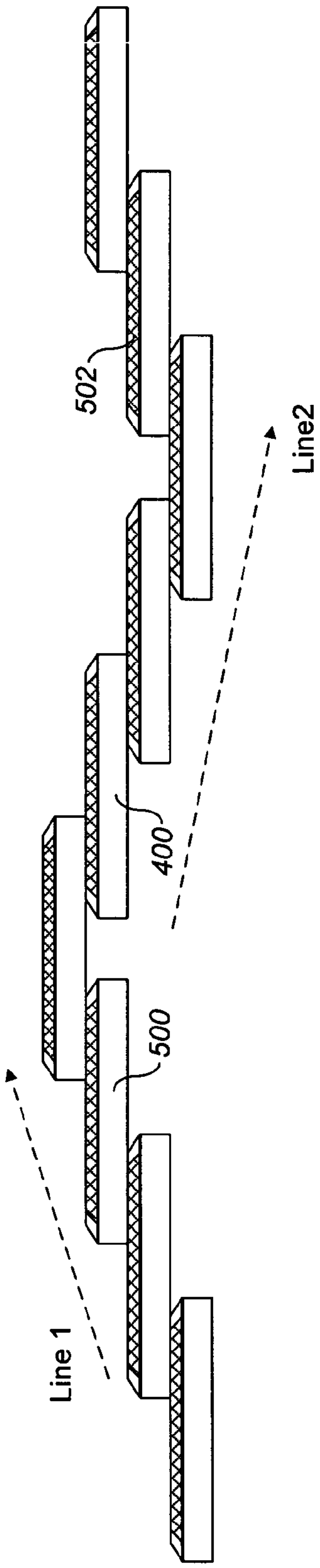


FIG. 6

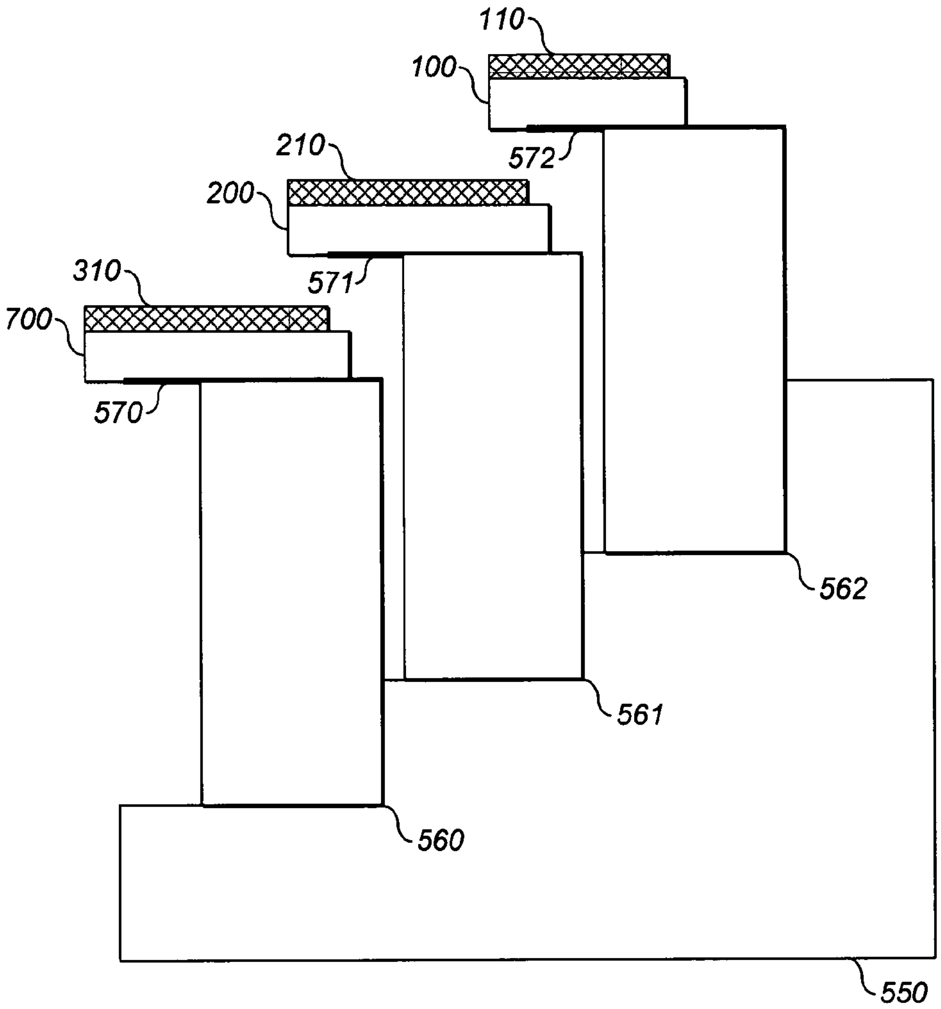


FIG. 7

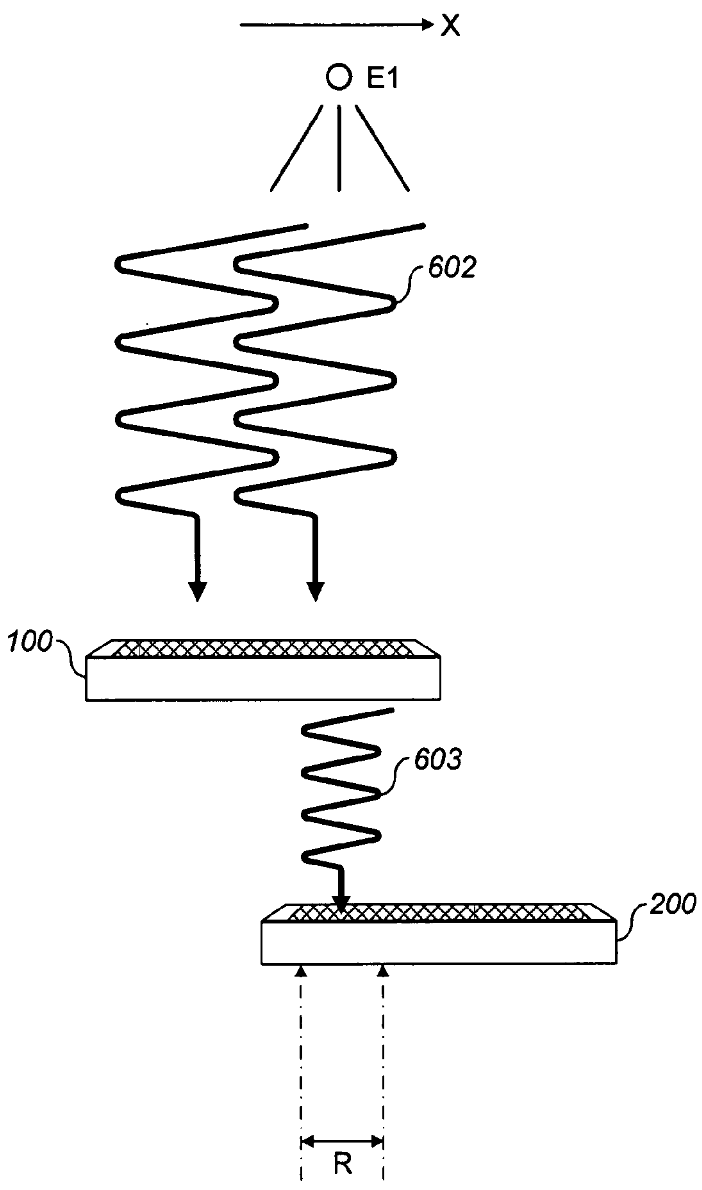


FIG. 8

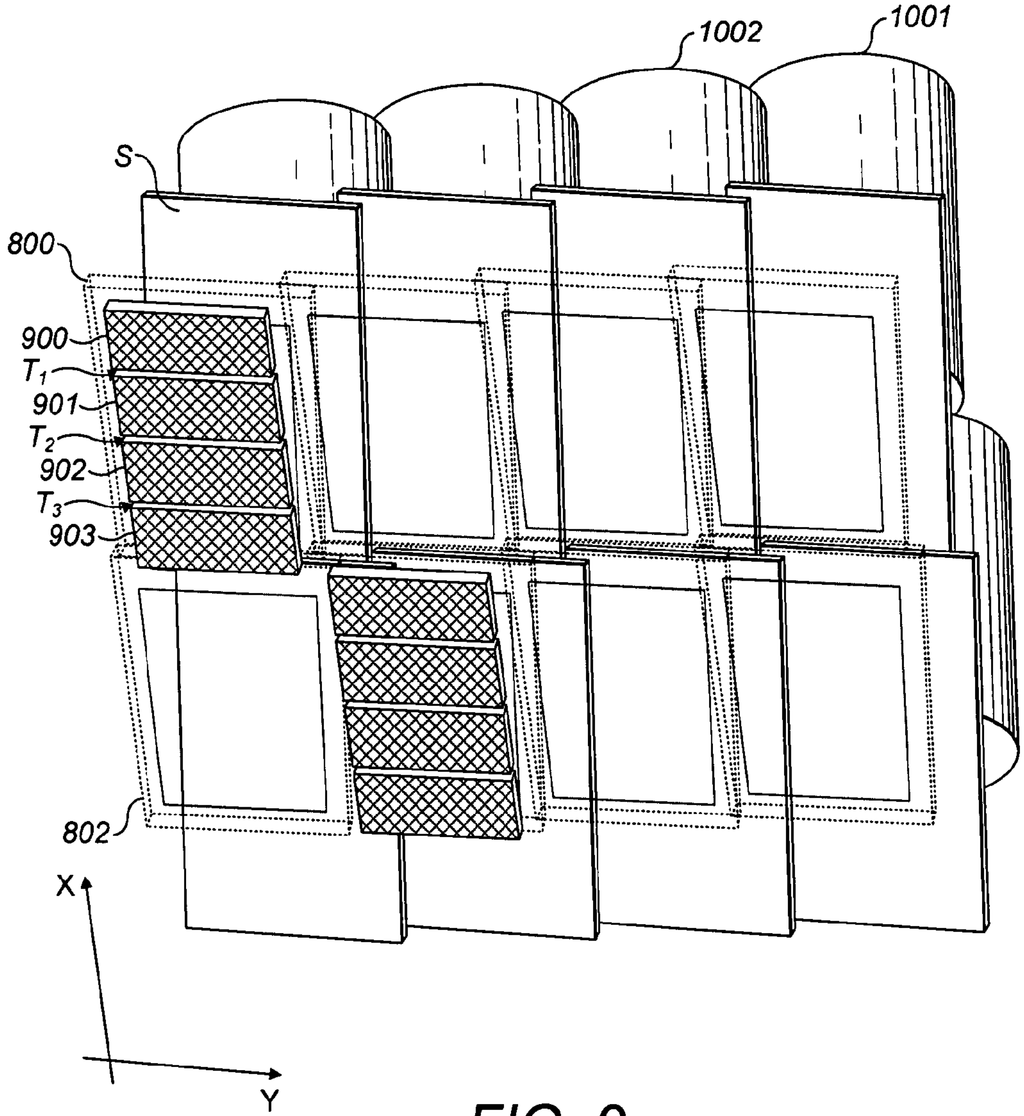
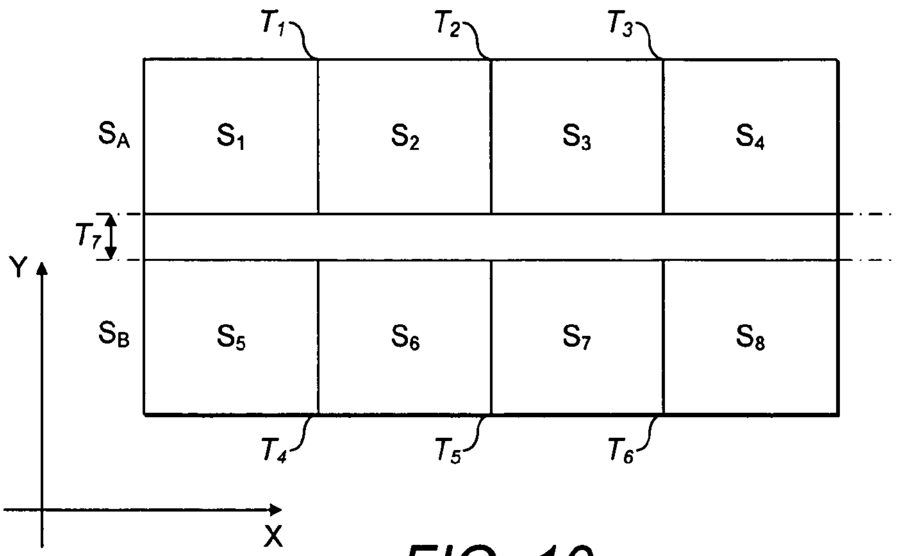


FIG. 9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T3
SA
S1
S2
S3
S4
T7
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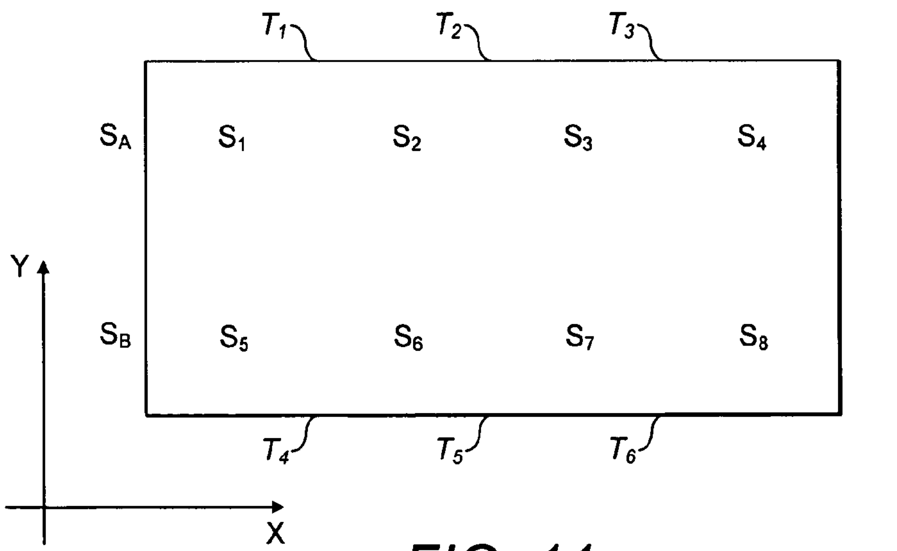
SB
S5
S6
S7
S8
T4
T5
T6
X

FIG. 10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T6
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FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/063880

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B6/00 G01T1/24 H01L27/148 H04N3/15 H04N5/335

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)
H04N A61B G01T H01L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 467 226 A (AGFA GEVAERT [BE]) 13 October 2004 (2004-10-13) abstract; figures 4,5 paragraphs [0038], [0039], [0044] - [0050]	1-27
X	GB 2 289 983 A (SIMAGE OY [FI]) 6 December 1995 (1995-12-06) abstract; figures 1,3-5 page 23, line 24 - page 24, line 34	1-27
X	JP 2002 058669 A (MATSUSHITA ELECTRIC IND CO LTD) 26 February 2002 (2002-02-26) abstract; figures 4,5	1-27

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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	Date of mailing of the international search report
21 March 2007	28/03/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/063880

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	JP 63 040381 A (TOKYO SHIBAURA ELECTRIC CO) 20 February 1988 (1988-02-20) abstract; figures 1,2	1-27
A	GB 2 315 157 A (SIMAGE OY [FI]) 21 January 1998 (1998-01-21) abstract; figures 1-3	1-27
A	US 4 467 342 A1 (TOWER JOHN R [US]) 21 August 1984 (1984-08-21) abstract; figure 4	1-27

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Information on patent family members

International application No
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