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(54) Title: COATING DEVICE FOR PRODUCTION OF A RADIOGRAPHY FLAT PANEL DETECTOR AND METHOD OF PRODUCTION.

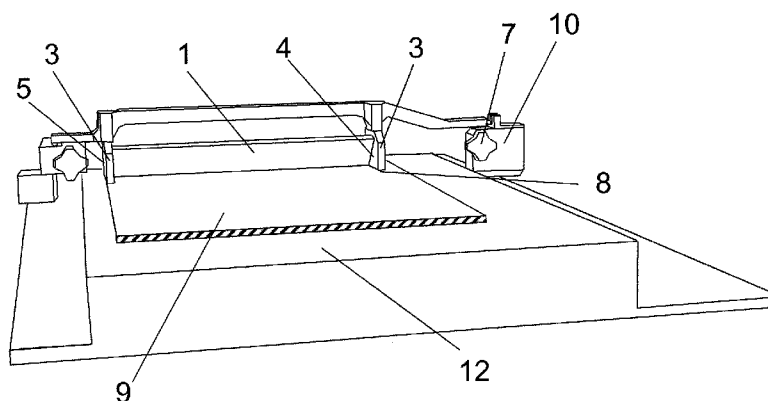


Fig.1

(57) Abstract: A method of manufacturing a radiography flat panel detector comprising the coating of a coating dispersion of scintillator particles on a sensor panel by means of a coating device comprising a carriage, the carriage containing a blade (1) connected to a pair of opposing side-walls (3), the side-walls having an inner side (4), an outer side (5) and a under side, means for height adjustment (7) in order to obtain a first gap between the under side of the side-walls and the surface of the support (9), a second gap between the blade and the support, the device further contains means (10) for lateral moving the carriage relative to the support in the coating direction, so as to maintain the gap between the under side of the side- walls (6) and the surface of the sensor panel.



Coating device for production of a radiography flat panel detector and method of production.

Technical Field

[0001] The invention relates to radiography X-ray detectors having a scintillator directly deposited on top of a sensor panel and the method of producing the same.

Background Art

[0002] X-ray imaging is a non-invasive technique to capture medical images of patients or animals as well as to inspect the contents of sealed containers, such as luggage, packages, and other parcels. To capture these images, an X-ray beam irradiates an object. The X-rays are then attenuated as they pass through the object. The degree of attenuation varies across the object as a result of variances in the internal composition and/or thickness of the object. The attenuated X-ray beam impinges upon an X-ray detector designed to convert the attenuated beam to a usable shadow image of the internal structure of the object.

[0003] Increasingly, radiography flat panel detectors (RFPDs) are being used to capture images of objects during inspection procedures or of body parts of patients to be analyzed. These detectors can convert the X-rays directly into electric charges (direct conversion direct radiography - DCDR), or in an indirect way (indirect conversion direct radiography - ICDR).

[0004] In direct conversion direct radiography, the RFPDs convert X-rays directly into electric charges. The X-rays are directly interacting with a photoconductive layer such as amorphous selenium (a-Se).

[0005] In indirect conversion direct radiography, the RFPDs have a scintillating scintillator such as CsI:TI (caesium iodide doped with thallium) or Gd₂O₂S (gadolinium oxysulphide, GOS) which converts X-rays into light which then interacts with an amorphous silicon (a-Si) semiconductor layer, where electric charges are created.

[0006] The created electric charges are collected via a switching array, comprising thin film transistors (TFTs). The transistors are switched-on row by row and column by column to read out the signal of the detector.

The charges are transformed into voltage, which is converted in a digital number that is stored in a computer file which can be used to generate a softcopy or hardcopy image. The array of TFTs together with the amorphous Si-layer is called photoelectrical conversion elements.

- [0007] The electronic components to switch the TFTs and read out and process the signals are positioned onto the support carrying the TFT and forming the sensor panel. This support of the sensor panel is usually glass, but can also be made from flexible material such as plastic foil made of PET etc.
- [0008] The TFTs are connected with conduction lines with electronic components comprising driving circuits of the TFTs and signal processing circuits. These electronic components can be connected with the sensor panel by means of flexible connectors, but it is cheaper and more efficient to put these electronic components directly onto the support of the sensor panel. If this support is glass, this technology is called 'Chip-on-glass'. Chip-on-glass is very cost effective and reliable, and starts to be more and more implemented in RFPDs.
- [0009] GOS is one of the most used scintillators in RFPDs due to their low cost and easy preparation method. GOS is usually coated on the flexible support and coupled to the TFT.
- [0010] The detector of the RFPD is usually TFT on the support (glass, flexible, etc.) and the electronic elements are attached to the support on the edges of the support. Since GOS still needs to be coupled to the TFT, the gluing possibility are become limited by the electronic components. In this case the cold lamination with PSA (pressure sensitive adhesive) the industrial lamination with specialized equipment is not possible due to inhomogeneous pressure over the surface and possibility to damage electronics. Hot lamination is not recommended due to the possible damage to the detector (TFT and electronic components). The only possibility is gluing each TFT and scintillator by operator, which requires high precision and is very time consuming.
- [0011] Gluing the scintillator onto the TFT has an additional disadvantage due to the adhesive layers commercially available, having a thickness of 20 to 50 μm in between the scintillator and the TFT, light originating from the

scintillator can spread before attaining the TFT, resulting in a loss of sharpness of the image.

- [0012] Therefore, methods of direct depositing the scintillator onto the TFT have been developed: WO15064043A1 describes the application of a paste comprising binder and scintillator particles of $\text{Gd}_2\text{O}_2\text{S}$ onto the sensor panel by means of a slit coater.
- [0013] US2014/0034836A1 describes the application of a paste comprising a resin and scintillator particles covering the pixel array of the sensor panel by means of slit-coating, screen printing or die coating.
- [0014] US8941074B discloses the application of GOS material onto the sensor array by using a slit coat method. A peeling tape at the outer periphery of the sensor panel is used to obtain a uniform layer thickness of the scintillator containing layer by peeling off the tape after the application of the scintillator layer. However, the disadvantage of the use of tape is that rests of adhesive remain on the support which can cause problems of adhesion and electrical connectivity between the chips and the TFT.
- [0015] None of the above mentioned documents describe a method which can be used to apply scintillator particles onto an imaging array when the electronic components for processing the signals from the TFT are already present onto the support of the imaging array. The method of application as described can not be used when the electronic components are already positioned on the support of the sensor panel because the tips of the slit coater or die coater or the squeegee used with screen printing, which is only removed from the surface of the support for some μm would touch the electronic components. Narrowing the slit coaters or die coaters or squeegee to prevent contact with the electronic components would result in a coating width of the scintillator particles being much smaller than the useful area of the sensor panel. This results in a smaller imageable area of the detector.
- [0016] Moreover, simply narrowing the coaters or squeegee result in a coating with non-straight coating edges and non-uniform coating thickness at the edges of the scintillator layer. These disadvantages result in a non-uniform luminescence efficiency at the periphery of the scintillator layer.

electronic components. Narrowing the slit coaters or die coaters or squeegee to prevent contact with the electronic components would result in a coating width of the scintillator particles being much smaller than the useful area of the sensor panel. This results in a smaller imageable area of the detector.

[0018] Moreover, simply narrowing the coaters or squeegee result in a coating with non-straight coating edges and non-uniform coating thickness at the edges of the scintillator layer. These disadvantages result in a non-uniform luminescence efficiency at the periphery of the scintillator layer.

Summary of invention

[0019] It is an object of the invention to provide a method of applying scintillator particles onto a sensor panel which contains electronic components for driving the TFTs of the sensor panel and for signal processing, thereby maximising the area for conversion of X-rays into electrical signals of the detector and providing uniformity of coating thickness at the periphery of the scintillator layer and a straight coating edges.

[0020] The objection of the invention is realised by the coating device as described in claim 1.

[0021] It is a further objection of the invention to provide a method of applying scintillator layers onto a sensor panel using the coating device of claim 1. This method is described in claim 5.

[0022] Other features, elements, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention. Specific embodiments of the invention are also defined in the dependent claims.

Brief description of drawings

[0023] Fig.1: Coating device according to the invention:

[0024] a carriage containing:

- a blade (1)
- a pair of opposing side-walls (3) extending into the coating direction
- an inner side (4) of the side-walls
- an outer side (5) of the side-walls

- means for height adjustment (7) in order to obtain a first gap (8) between the under side of the side-walls and the surface of the support (9),
- means (10) for lateral moving the carriage relative to the support in the coating direction
- a bottom plate (12)

[0025] Fig.2: Preferred embodiment of the coating device according to the invention, comprising:

- slots (2)
- side-walls (3) having an inner side (4) and an under side (6)
- a first gap (8) between the under side of the side-walls and the surface of the support (9)
- a second gap (11) between the blade and the support

[0026] Fig. 3: Sensor panel comprising an array of photoelectric conversion elements and electronic components

- Support of the sensor panel(13)
- Array of photoelectric conversion elements (14)
- Electronic components which may contain the driver circuits for the photoelectric conversion elements and the circuits for the signal processing of the TFTs, and protruding from the surface of the support (15)

[0027] Fig. 4: Side-walls of the coating device according to an embodiment of the invention:

- Blade (1)
- Support of the sensor panel (13)
- One of the side-walls (3) of the carriage
- Outer side of the side-wall (5)
- Electronic components (15) protruding from the surface of the support of the sensor panel

- Part of the outer side of at least one side-wall (16) showing an angle with the surface of the support, measured at the outer-side of the side-wall, of less than 90°.

Description of embodiments

Method of applying scintillator particles onto a sensor panel

[0028] A layer of scintillator particles directly in contact with the sensor panel according to the present invention can be obtained by applying a dispersion comprising scintillator particles by means of the coating device described below of which a preferred embodiment is shown in Figure 1. The coating dispersion comprises scintillator particles, a binder and a solvent.

[0029] The sensor panel is fixed onto the bottom plate (12) of the coating device. After stirring or homogenization an amount of coating dispersion is poured onto the upper surface (9) of the sensor panel, preferably as close as possible to the blade (1) of the coating device. A sensor panel comprising an array of photoelectric conversion elements which define the imageable area (14) onto the support (13) and which also comprises electronic components (15) surrounding the image area is shown in Figure 2. The upper surface of the panel is the side comprising the array of photoelectric conversion elements. The desired wet coating thickness, is obtained by adjusting the gap (11) between the upper surface of the sensor panel and the blade of the coating device. In order to prevent flow of the coating dispersion beyond the outer side of side-walls, the height of the gap (8) between the under side of the side-walls and the upper surface of the sensor panel is adjusted. The required height of the gap between the under side of the side-walls and the upper surface of the sensor panel depends on the viscosity of the coating dispersion. Useful coating dispersions comprising scintillator particles may have a viscosity between 250 cP and 3000cP (250-3000 mPa.s). The corresponding height range of

the gap between the under side of the side-walls and the surface of the sensor panel is between 100 μ m and 1000 μ m, preferably between 200 μ m and 750 μ m.

- [0030] The carriage moves then forward into the coating direction in such a way that a lateral movement takes place of the blade and of the side-walls and that hereby the gap (8) between the under side of the side walls and the surface of the substrate is maintained during the movement. The coating dispersion is spread over the sensor panel and the coating dispersion is prevented to flow beyond the outer side of the side walls and hence prevent in flowing beyond the useful area of the sensor panel defined by the array of the photoelectric conversion elements (14). An advantage of the invention is that less coating dispersion is lost because of flow into the region of the electronic components of the sensor panel or flow from the edges of the panel than with a coating method not having these side-walls. The transport of the carriage can be driven manually or by a motor.
- [0031] In a preferred embodiment of the method, the outer-side walls match with the edge of the imageable area of the sensor plate.
- [0032] After the coating of the film comprising the scintillator particles, this layer can be dried via an IR-source, an UV-source, a heated bottom plate or heated air. When photo-curable monomers are used in the coating dispersion, the coated layer can be cured via heating or via an UV-source.

Coating device

- [0033] The coating device of the present invention comprises a carriage containing a blade (1). The blade is preferably a metal blade. The blade is fixed to a pair of side-walls opposing each other. The blade can be an integral part of the side-walls. Preferably, the blade is fitted into slots (2) of a pair of opposing side-walls (3) which are made of a metal, preferably stainless steel. The side-walls have an inner side (4), an outer side (5) and an under side (6), the slots being present at the inner side of the side-walls. The carriage comprises further means for height adjustment (7) of the side-walls in order to obtain a first gap (8) between the under side of

the side-walls and the upper surface of the support (9). The height of the gap is chosen in such a way as to obtain no coating dispersion flow beyond the outer side of the side walls prior and during the lateral movement of the carriage. The blade is connected to the side-wall in such a way that a second gap (11) is obtained between the blade and the support. The carriage may contain means for adjusting the height of the second gap (11) independently from the height of the first gap (8). If the blade fits into slots, the height can be adjusted such as to obtain a second gap, independently from the first gap. The flow of the coating dispersion and thickness of the coated layer can then be better optimised. Preferably, this gap is equal in height as the first gap (8). The coating device further comprises means (10) for lateral moving the carriage relative to the support, so as to maintain the gap between the under side of the side-walls and the support during the movement. All means for transporting a carriage lateral to the support can be used. Preferably these means comprise gliders, rails or beads. The coating device further comprising a bottom plate (12) which whereon the support can be fixed such that the support does not move during the lateral movement of the carriage. Preferably, this bottom plate is a metal plate. The fixation of the support can be done by any fixation means, preferably by means of vacuum. In the last case holes or grooves are comprised in the bottom plate.

[0034] A preferred embodiment of the invention is a coating device as described above but wherein a part of the outer side of at least one side-wall (16) shows an angle with the surface of the support, measured at the outer-side of the side-wall, of less than 90° . This allows to further widen the blade without risking that the outer side of the side-wall contacts the electronic components around the imageable area of the sensor panel.

[0035] Another preferred embodiment of the invention is a coating device wherein the side-walls make an integral part of the coating blade such as to form a U-shaped coating blade. Both ends on the U-shaped blade extend in the coating direction. The advantage of a coating device wherein the side-walls make an integral part of the coating blade is that the construction of it is much easier than if the blade does not make an integral part of the side

walls.

The scintillator layer

- [0036] The scintillator particles, which can be applied onto the sensor panel according to the present invention are: $(Y,Gd)_2O_3:Eu,Pr$; $Gd_2O_2S:Pr,Ce,F$; and $Gd_3Ga_5O_{12}:Cr,Ce$, $BaHfO_3:Ce$, Ceramic scintillators such as $(Y,Gd)_2O_3:Eu$ have been tailor-made for use in both medical and industrial X-ray detectors for CT-scanning applications (Annu. Rev. Mater. Sci. 1997. 27:69–88, CERAMIC SCINTILLATORS, C. Greskovich and S. Duclos).
- [0037] More preferably, the scintillator particles can be selected from the group consisting of $Gd_2O_2S:Tb$, $Gd_2O_2S:Eu$, $Gd_2O_3:Eu$, $La_2O_2S:Tb$, La_2O_2S , $Y_2O_2S:Tb$, $CsI:TI$, $CsI:Eu$, $CsI:Na$, $CsBr:TI$, $NaI:TI$, $CaWO_4$, $CaWO_4:Tb$, $BaFBr:Eu$, $BaFCl:Eu$, $BaSO_4:Eu$, $BaSrSO_4$, $BaPbSO_4$, $BaAl_{12}O_{19}:Mn$, $BaMgAl_{10}O_{17}:Eu$, $Zn_2SiO_4:Mn$, $(Zn, Cd)S:Ag$, $LaOBr$, $LaOBr:Tm$, $Lu_2O_2S:Eu$, $Lu_2O_2S:Tb$, $LuTaO_4$, $HfO_2:Ti$, $HfGeO_4:Ti$, $YTao_4$, $YTao_4:Gd$, $YTao_4:Nb$, $Y_2O_3:Eu$, $YBO_3:Eu$, $YBO_3:Tb$, $(Y,Gd)BO_3:Eu$, and combinations thereof.
- [0038] The median particle size of the scintillator particles is generally between about 0.5 μm and about 40 μm . A median particle size of between 1 μm and about 20 μm is preferred for ease of formulation, as well as optimizing properties, such as speed, sharpness and noise. The coating dispersion in the present invention can be prepared by using the scintillator powder, for example Gd_2O_2S and mix it with a solution of a binder material.
- [0039] The method of applying scintillator particles onto a sensor panel according to the invention is also suitable for organic scintillators. Examples of the organic scintillators which are suitable include anthracene, p-terphenyl, p-quaterphenyl, 2, 5-diphenyloxazol, 2,5-diphenyl-1, 3,4-oxadiazole, naphthalene, diphenylacetylene, and stilbenzene.
- [0040] The binder can be chosen from a variety of known organic polymers that are transparent to X-rays and emitting light. Binders commonly employed in the art include sodium o-sulfobenzaldehyde acetal of poly(vinyl alcohol);

chloro-sulfonated poly(ethylene); a mixture of macromolecular bisphenol poly(carbonates) and copolymers comprising bisphenol carbonates and poly(alkylene oxides); aqueous ethanol soluble nylons; poly(alkyl acrylates and methacrylates) and copolymers of poly(alkyl acrylates and methacrylates with acrylic and methacrylic acid); poly(vinyl butyral); and poly(urethane) elastomers.

- [0041] Preferred binders are organic polymers such as cellulose acetate butyrate, polyalkyl (meth)acrylates, polyvinyl-n-butyral, poly(vinylacetate-co-vinylchloride), poly(acrylonitrile-co-butadiene-co-styrene), poly(vinyl chloride-co-vinyl acetate-co-vinylalcohol), poly(butyl acrylate), poly(ethyl acrylate), poly(methacrylic acid), poly(vinyl butyral), trimellitic acid, butenedioic anhydride, phthalic anhydride, polyisoprene and/or a mixture thereof. Preferably, the binder comprises one or more styrene-hydrogenated diene block copolymers, having a saturated rubber block from polybutadiene or polyisoprene, as rubbery and/or elastomeric polymers. Particularly suitable thermoplastic rubbers, which can be used as block-copolymeric binders, in accordance with this invention, are the KRATON™ G rubbers, KRATON™ being a trade name from SHELL.
- [0042] Any conventional ratio scintillator to binder can be employed. Generally, the thinner the scintillator containing layers are, the sharper images are realized when a high weight ratio of scintillator to binder is employed. Scintillator-to-binder ratios in the range of about 70:30 to 99:1 by weight are preferable.
- [0043] The scintillators may be prepared in the present invention as powder dispersed in a binder. The amount of the binder in the scintillator layer in weight percent can vary in the range from 1% to 50%, preferably from 1% to 25%, more preferably from 1% to 10%, most preferably from 1% to 3%.
- [0044] Suitable binders are e.g. organic polymers or inorganic binding components. Examples of suitable organic polymers are polyethylene glycol acrylate, acrylic acid, butenoic acid, propenoic acid, urethane acrylate, hexanediol diacrylate, copolyester tetracrylate, methylated melamine, ethyl acetate, methyl methacrylate. Inorganic binding components may be used as well. Examples of suitable inorganic binding

components are alumina, silica or alumina nanoparticles, aluminium phosphate, sodium borate, barium phosphate, phosphoric acid, barium nitrate.

- [0045] In case the coating of the scintillator layer is to be cured, the binder includes preferably a polymerisable compound which can be a monofunctional or polyfunctional monomer, oligomer or polymer or a combination thereof. The polymerisable compounds may comprise one or more polymerisable groups, preferably radically polymerisable groups. Any polymerisable mono- or oligofunctional monomer or oligomer commonly known in the art may be employed. Preferred monofunctional monomers are described in **EP1637322A** paragraph [0054] to [0057]. Preferred oligofunctional monomers or oligomers are described in **EP1637322A** paragraphs [0059] to [0064]. Particularly preferred polymerisable compound are urethane (meth)acrylates and 1,6-hexanedioldiacrylate. The urethane (meth)acrylates are oligomer which may have one, two, three or more polymerisable groups.
- [0046] Suitable solvents, to dissolve the during the preparation of the coating dispersion can be acetone, hexane, methyl acetate, ethyl acetate, isopropanol, methoxy propanol, isobutyl acetate, ethanol, methanol, methylene chloride and water. The most preferable ones are toluene, methyl-ethyl-ketone (MEK) and methyl cyclohexane. To dissolve suitable inorganic binding components, water is preferable as the main solvent. In case of a curable coating dispersion, one or more mono and/or difunctional monomers and/or oligomers can be used as diluents. Preferred monomers and/or oligomers acting as diluents are miscible with the above described urethane (meth)acrylate oligomers. The monomer(s) or oligomer(s) used as diluents are preferably low viscosity acrylate monomer(s).
- [0047] In a preferred embodiment the coating dispersion is prepared by first dissolving the binder in a suitable solvent. To this solution the scintillator powder material is added. To obtain a homogenous coating dispersion, a homogenization step or milling step of the mixture can be included in the preparation process. A dispersant can be added to the binder solution

prior to the mixing with the scintillating powder material. The dispersant improves the separation of the particles in the coating dispersion and prevents settling or clumping of the ingredients in the coating dispersion. The addition of dispersants to the coating dispersion of the scintillator layer further decreases the surface tension of the coating dispersion and improves the coating quality of the scintillator layer.

- [0048] Dispersants which can be used in the present invention include non-surface active polymers or surface-active substances such as surfactants, added to the binder to improve the separation of the scintillator particles to further prevent settling or clumping in the coating dispersion. Suitable examples of dispersants are Stann JF95B from Sakyo and Disperse Ayd™ 1900 from Daniel Produkts Company. The addition of dispersants to the coating dispersion of the X-ray absorbing layer improves further the homogeneity of the layer.
- [0049] The scintillator layer of the present invention may also comprise additional compounds such as plasticizers, photoinitiators, photocurable monomers, antistatic agents, surfactants, stabilizers oxidizing agents, adhesive agents, blocking agents and/or elastomers.
- [0050] Suitable examples of plasticizers are Plastilit™ 3060 from BASF, Santicizer™ 278 from Solutia Europe and Palatinol™ C from BASF. The presence of plasticizers to the X-ray absorbing layer improves the compatibility with flexible substrates.
- [0051] Suitable photo-initiators are disclosed in e.g. J.V. Crivello et al. in "Photoinitiators for Free Radical, Cationic & Anionic Photopolymerisation 2nd edition", Volume III of the Wiley/SITA Series In Surface Coatings Technology, edited by G. Bradley and published in 1998 by John Wiley and Sons Ltd London, pages 276 to 294. Examples of suitable photoinitiators can be Darocure™ 1173 and Nuvopol™ PI-3000 from Rahn. Examples of suitable antistatic agents can be Cyastat™ SN50 from Acris and Lanco™ STAT K 100N from Langer.
- [0052] Examples of suitable surfactants can be Dow Corning™ 190 and Gafac RM710, Rhodafac™ RS-710 from Rodia. Examples of suitable stabilizer compounds can be Brij™ 72 from ICI Surfactants and Barostab™ MS from

Baerlocher Italia. An example of a suitable oxidizing agent can be lead (IV) oxide from Riedel De Haen. Examples of suitable adhesive agents can be Craynor™ 435 from Cray Valley and Lanco™ wax TF1780 from Noveon. An example of a suitable blocking agent can be Trixene™ BI7951 from Baxenden. An example of a suitable elastomer compound can be Metaline™ from Schramm).

[0053] Depending on the application, the coating weight of the scintillator can be flexibly adjusted and in case of using a RFPD for general medical purposes, this coating weight is preferably at least 100 mg/cm², more preferably at least 150 mg/cm².

[0054] The thickness of the scintillator can vary as well and depends on the application (CT, CBCT, GENERAL, mammo) of the RFPD. In the present invention, the thickness of the scintillator absorbing layer can be at least 0.1 mm, more preferably in the range from 0.1 mm to 2.0 mm.

The sensor panel

[0055] The sensor panel used in the invention for indirect conversion direct radiography is based on an indirect conversion process which uses several physical components to convert X-rays into light that is subsequently converted into electrical charges. The first component is a scintillator which converts X-rays into light (photons). Light is further guided towards an amorphous silicon photodiode layer which converts light into electrons and electrical charges are created. The charges are collected and stored by the storage capacitors. A thin-film transistor (TFT) array adjacent to amorphous silicon read out the electrical charges and an image is created. This forms an array of photoelectric elements. The array of TFTs, together with the amorphous Si-layer, are called photoelectrical conversion elements and are positioned onto a support. The support of the photoelectrical conversion elements is usually glass, but can also be made from flexible material such as plastic foil made of PET. The array of photoelectric conversion elements forms the imageable area of the sensor panel.

- [0056] Examples of suitable sensor panels are disclosed in US5262649 and by Samei E. et al., "General guidelines for purchasing and acceptance testing of PACS equipment", Radiographics, 24, 313-334 . Preferably, the imaging arrays as described in US2013/0048866, paragraph [90-125] and US2013/221230, paragraphs [53-71] and [81-104] can be used.
- [0057] For indirect conversion process, the charges must be read out by readout electronics. Examples of readout electronics in which the electrical charges produced and stored are read out row by row, are disclosed by Samei E. et al., Advances in Digital Radiography. RSNA Categorical Course in Diagnostic Radiology Physics (p. 49-61) Oak Brook, Ill.
- [0058] The substrate of the imaging array of the present invention is preferably glass. However, imaging arrays fabricated on substrates made of plastics, metal foils can also be used. The imaging array can be protected from humidity and environmental factors by a layer of silicon nitride or polymer based coatings such as fluoropolymers, polyimides, polyamides, polyurethanes and epoxy resins. Also polymers based on B-staged bisbenzocyclobutene-based (BCB) monomers can be used. Alternatively, porous inorganic dielectrics with low dielectric constants can also be used.
- [0059] The electronic components to switch the TFT's and read out and process the signals are preferably positioned onto the support carrying the TFT and forming the sensor panel. The TFT's are connected with conduction lines to electronic components comprising driving circuits of the TFT's and signal processing circuits. If this support is glass, this technology is called 'Chip-on-glass'.
- [0060] Chip-On-Glass (COG) is a flip chip bonding technology for direct connection assembly of bare electronic components such as integrated circuits (ICs) on glass substrate by using Anisotropic Conductive Film (ACF). This technology reduces the assembly area to the highest possible packing density, reducing considerably the area of the glass support of the RFPD. It allows a cost-effective mounting of driver and processing electronic components, because flexibles to the PCB are no longer required. The electronic components are bonded directly onto the glass support and are suitable for handling high-speed signals from the TFTs.

The chip-on glass technology is also suitable for source driver ICs for the TFT array.

[0061] While the present invention will hereinafter in the examples be described in connection with preferred embodiments thereof, it will be understood that it is not intended to limit the invention to those embodiments.

EXAMPLES

[0062] Most materials used in the following examples were readily available from standard sources such as ALDRICH CHEMICAL Co. (Belgium), ACROS (Belgium) and BASF (Belgium) unless otherwise specified. All materials were used without further purification unless otherwise specified.

- GOS: Gadolinium oxysulphide doped with Terbium ($Gd_2O_2S:Tb$) or ($GOS:Tb = CAS\ 68609-43-8$) powder was obtained from Nichia, mean particle size: $3.3\ \mu m$;
- Kraton™ FG1901X (new name = Kraton™ FG1901 GT), a clear, linear triblock copolymer based on styrene and ethylene/butylene with a polystyrene content of 30%, from Shell Chemicals.
- Sensor panel: TFT coated with a-Si (according US2013/0048866, paragraph [90-125] and US2013/221230, paragraphs [53-71] and [81-104]) on Corning Lotus™ Glass support having a thickness of 0.7 mm and a size of 43cm X 35 cm. The size of the array of photoelectric conversion elements (imageable area) is 34 x 42 cm.

Preparation of the coating dispersion

[0063] 18 g of binder (Kraton™ FG1901X) was dissolved in 72 g of a solvent mixture of toluene and MEK (ratio 75:25 (wt.)) and stirred for 15 min at a rate of 1900 r.p.m. The GOS was added thereafter in an amount of 800g and the mixture was stirred for another 30 minutes at a rate of 1900 r.p.m. The obtained GOS : binder weight ratio is 97.8 : 2.2.

Coating method with a coating knife having no side-walls (Comparative)

[0064] The sensor panel was fixed onto the bottom plate of a coating device having a carriage containing a doctor blade but having no side-walls connected to the blade. The length of the blade is 340 mm to cover the imageable area of the panel. The fixation of the panel to the bottom plate was done by means of a vacuum of 5×10^{-2} mbar. An amount of 50 to 70 ml of coating dispersion as obtained in the section 'Preparation of the coating dispersion' was poured onto the surface of the sensor panel. The coating dispersion was spread with the doctor blade moving forward in the coating direction at a coating speed of 1.4 cm/s over the area containing the array of photoelectric conversion elements (=imageable area). The transport of the carriage was provided by means of an electric motor. A wet coating thickness of 250 μm of the scintillator containing layer was obtained by adjusting the distance between the lower edge of the coating blade and the support to 250 μm . Subsequently, the scintillator layer was dried at room temperature, the support remaining attached at the coating device for maximum of 10 min. The edges of the obtained scintillator layer showed no straight line in the coating direction. Indeed, parts of the array of photoelectric conversion elements were not covered by the scintillator layer and parts of the area of the sensor panel containing the electronic components were covered by the coated scintillated layer. The thickness of the edges of the scintillator layer was twice the thickness of the centre part of the scintillator layer.

Coating method with a coating device according to the invention.

[0065] The sensor panel was fixed onto the bottom plate of the coating device of Fig1. The fixation of the panel to the bottom plate was done by means of a vacuum of 5×10^{-2} mbar. The length of the blade was 320 mm, and the thickness of the side walls amounts to 10mm. The height of the gap between the under side of the side-walls and the support was adjusted to 250 μm . An amount of 50 to 70 ml of coating dispersion as obtained in the

section 'Preparation of the coating dispersion' was poured onto the surface of the sensor panel, and then spread with the carriage moving forward into the coating direction at a coating speed of 1.4 cm/s over the area containing the array of photoelectric conversion elements (=imageable area). The wet thickness of 250 μm of the coated layer was obtained by adjusting the distance between the coating blade and the support to 250 μm . The transport of the carriage was provided by means of an electric motor. Subsequently, the scintillator layer was dried at room temperature, the support remaining attached at the coating device for maximum of 10 min. The edges of the obtained coating showed a straight line which corresponded with the periphery of the array of photoelectric conversion elements of the sensor panel. The thickness of the edges of the scintillator layer were the same as the thickness of the centre part of the scintillator layer. As can be seen, the method of coating scintillator particles onto a sensor panel according to the method of the invention decreases significantly the difference in coating thickness between the edges and the inner part of the scintillator layer, leading to a more homogeneous image formation by the detector.

Claims

- Claim 1. A coating device comprising a carriage, the carriage containing a blade (1) connected to a pair of opposing side-walls (3), the side-walls having an inner side (4), an outer side (5) and a under side (6), means for height adjustment (7) in order to obtain a first gap (8) between the under side of the side-walls and the surface of the support (9), a second gap (11) between the blade and the support, the device further contains means (10) for lateral moving the carriage relative to the support in the coating direction, so as to maintain the gap between the under side of the side-walls (6) and the surface of the support (9) during the movement.
- Claim 2. The coating device according to claim 1 wherein the blade (1) is fitted into slots (2) of the pair of opposing side-walls (3), the slots being present at the inner side of the side-walls.
- Claim 3. The coating device according to claim 1 wherein the side-walls make an integral part of the coating blade such as to form a U-shaped coating blade, the ends of the U-shaped blade extending in the coating direction.
- Claim 4. The coating device according to any of the preceding claims, wherein a part of the outer side of at least one side-wall (16) shows an angle with the surface of the support, measured at the outer-side of the side-wall, of less than 90°.
- Claim 5. A method of manufacturing a radiography flat panel detector comprising following steps:
- a) providing a sensor panel comprising photoelectric conversion elements (14) as a support of the coating device as defined in claim 1; and
 - b) providing a coating dispersion containing scintillator particles onto an upper surface of the sensor panel (9); and
 - c) moving the carriage of the coating device as defined in claim 1, in the direction of the coating dispersion, thereby spreading the coating dispersion as a layer onto the upper surface of the sensor panel; and
 - d) drying or curing the layer obtained in step c).
- Claim 6. The method of manufacturing a radiographic flat panel detector according to claim 5, wherein the height of the gap (8) between the under side

of the side-walls and the upper surface of the panel is chosen in such a way as to obtain no flow of coating dispersion beyond the outer-side of the side-walls.

Claim 7. The method of manufacturing a radiographic flat panel detector according to claim 6, wherein after the drying of the coated layer, a second coating dispersion is provided on the dried layer and steps c) to d) are repeated.

Claim 8. The method of manufacturing a radiographic flat panel detector according to claim 7, wherein the second coating dispersion comprises light reflecting particles.

Claim 9. The method of manufacturing a radiographic flat panel detector according to claim 10, wherein the light reflecting particles comprise TiO_2

Claim 10. The method of manufacturing a radiographic flat panel detector according to claims 5 to 9 wherein the scintillator particles comprise gadolinium oxysulphide.

Drawings

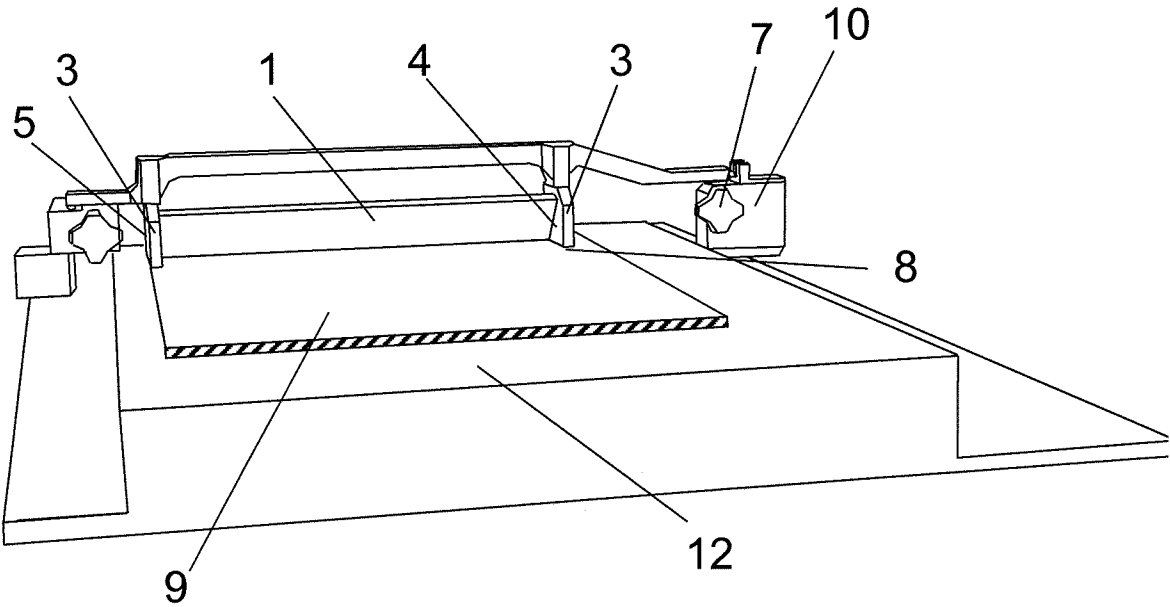


Fig.1

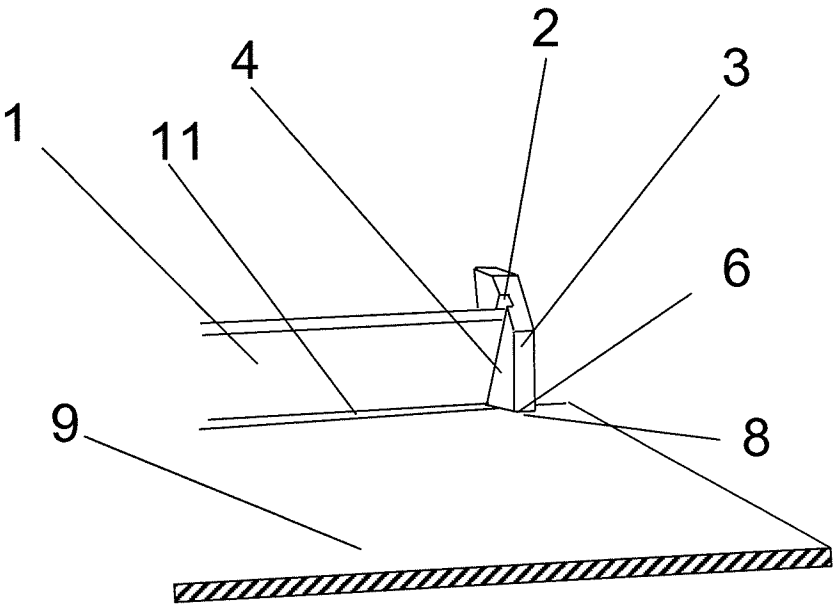


Fig. 2

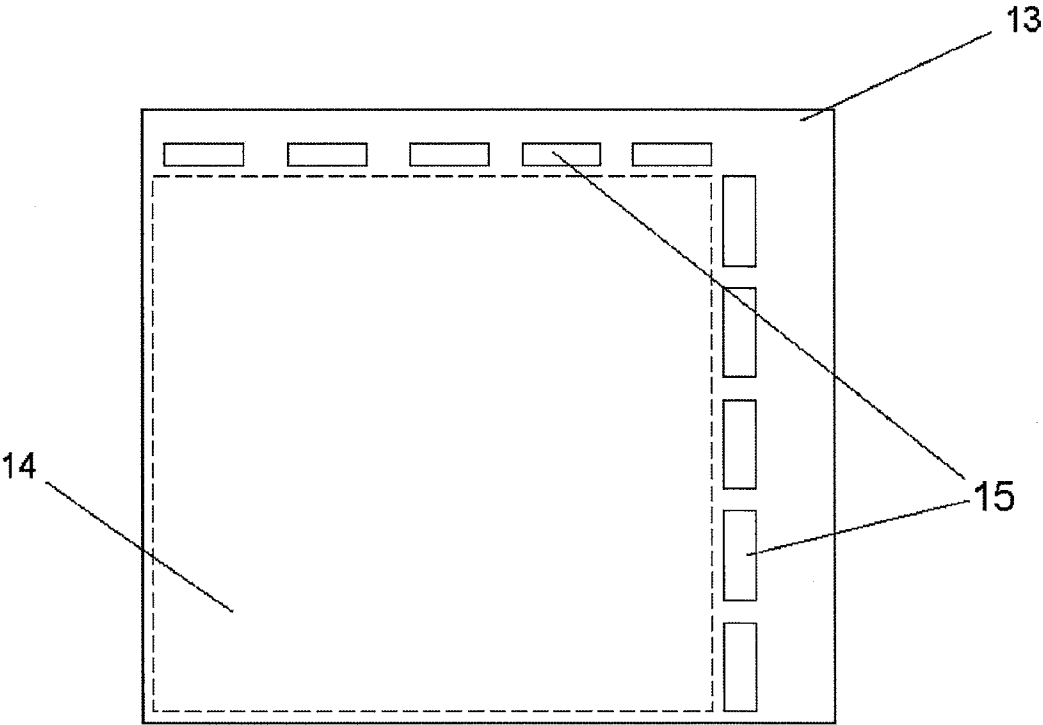


Fig. 3

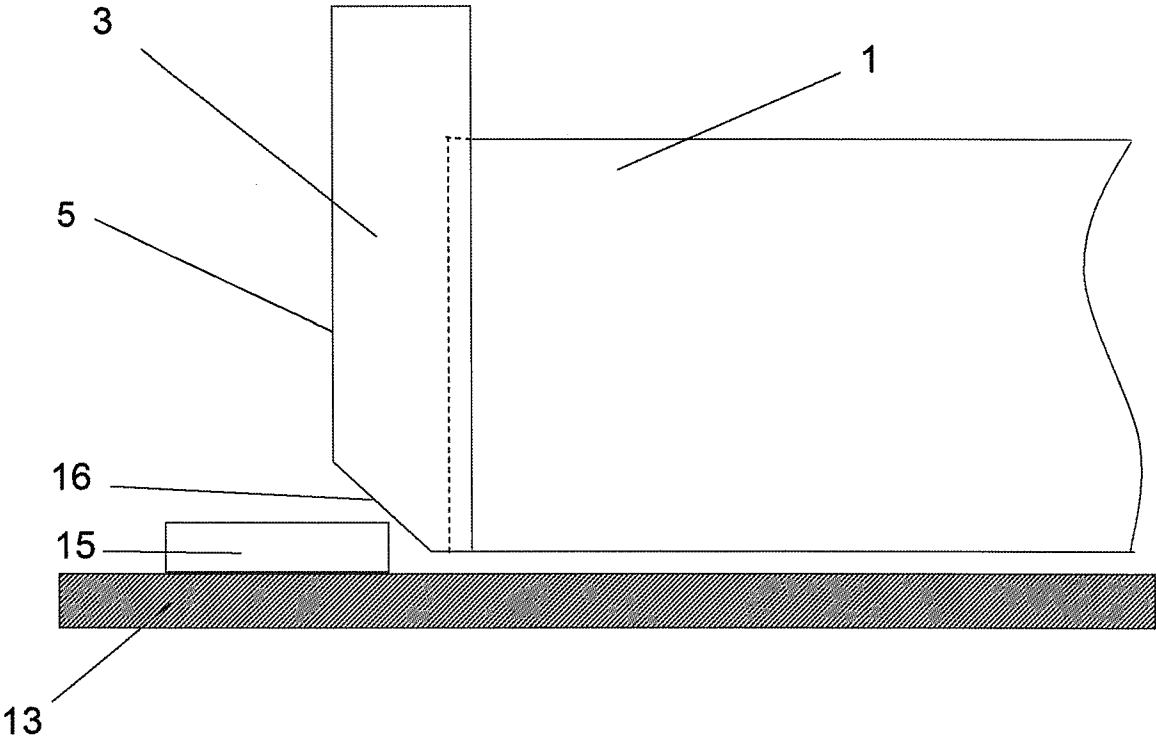


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/080725

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01T1/20
ADD.

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)
G01T B05C

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 practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2015 0058860 A (KOREA MACH & MATERIALS INST [KR]) 29 May 2015 (2015-05-29)	1,3,4
Y	figures 2, 3 paragraphs [0036], [0038], [0046] - [0050]	2,5-10
Y	----- WO 2015/091283 A1 (AGFA HEALTHCARE [BE]) 25 June 2015 (2015-06-25) figure 1 paragraphs [0041], [0047] - [0075]	5-10
Y	----- GB 2 208 813 A (XEROX CORP [US]) 19 April 1989 (1989-04-19) figure 4 -----	2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

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"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

1 March 2017

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/080725

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 20150058860 A	29-05-2015	KR 20150058860 A	29-05-2015
		WO 2015076466 A1	28-05-2015

WO 2015091283 A1	25-06-2015	CN 106104304 A	09-11-2016
		EP 3084476 A1	26-10-2016
		JP 2016540205 A	22-12-2016
		US 2016322411 A1	03-11-2016
		WO 2015091283 A1	25-06-2015

GB 2208813 A	19-04-1989	NONE	
