

[54] ELECTROPHOTOGRAPHIC METHOD OF IMAGING WITH AN ELEMENT CONTAINING AN AMORPHOUS SEMICONDUCTOR

[75] Inventors: Tatsuo Masaki, Tokyo; Hiroshi Hanada, Yokohama; Nobuo Kitashima, Tokyo, all of Japan

[73] Assignee: Canon Kabushiki Kaisha, Tokyo, Japan

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[63] Continuation of Ser. No. 43,535, June 4, 1970, abandoned.

[30] Foreign Application Priority Data

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Nov. 24, 1969 Japan..... 44-94093
Nov. 24, 1969 Japan..... 44-94094

[52] U.S. Cl. 96/1.5, 96/1 R

[51] Int. Cl. G03g 5/04

[58] Field of Search..... 96/1.5, 1 R, 1.7, 1.6

[56]

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Primary Examiner—Ronald H. Smith

Assistant Examiner—John L. Goodrow

Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57]

ABSTRACT

An electrophotographic photosensitive member which comprises mainly a base layer, an amorphous semiconductor capable of reversible transition between a highly resistive and conductive state, and a photoconductive layer. An electrophotographic process utilizing said photosensitive member produces images of high contrast and high resolving property.

6 Claims, 26 Drawing Figures

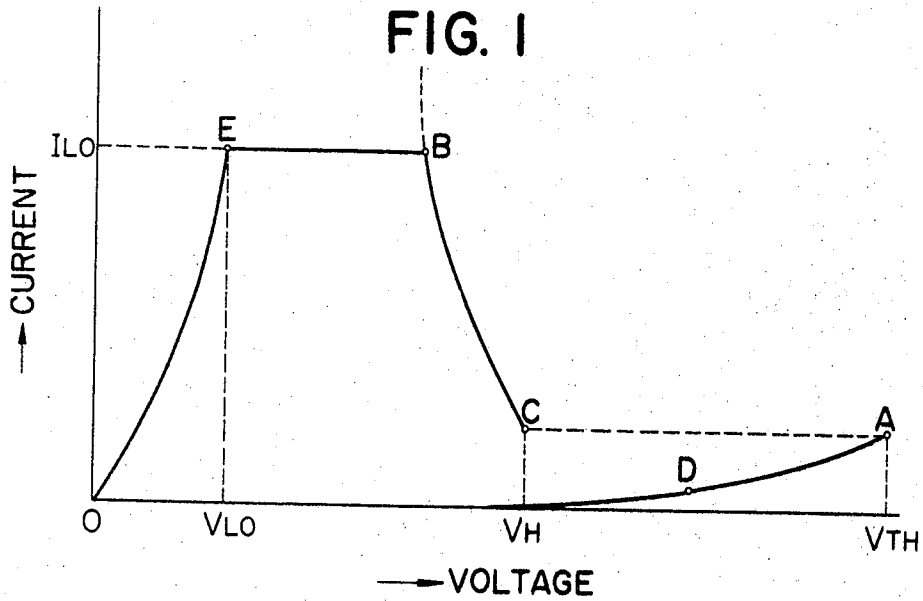
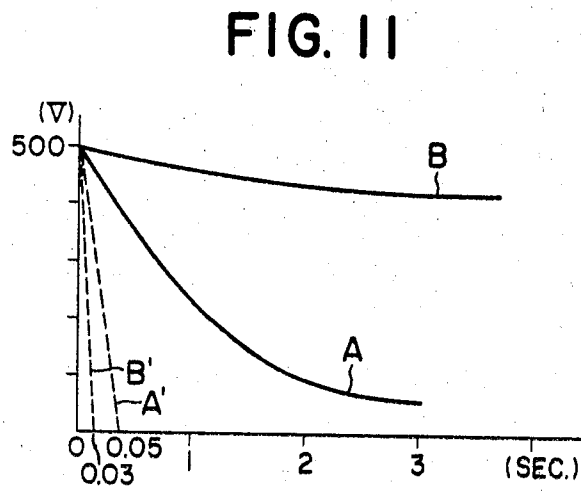


FIG. 2a

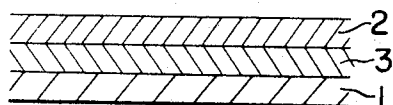


FIG. 2b

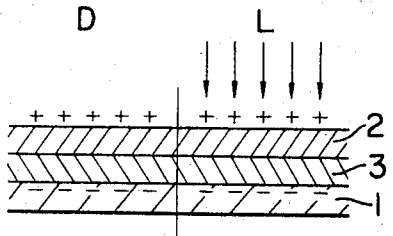


FIG. 2c

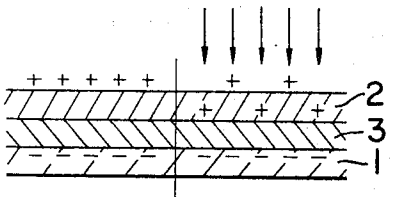


FIG. 2d

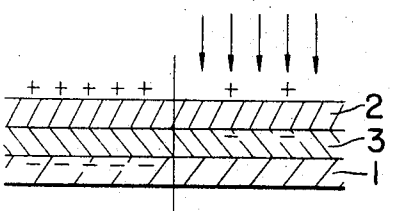


FIG. 2e

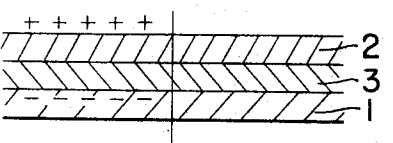


FIG. 3a

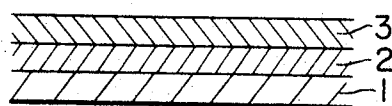


FIG. 3b

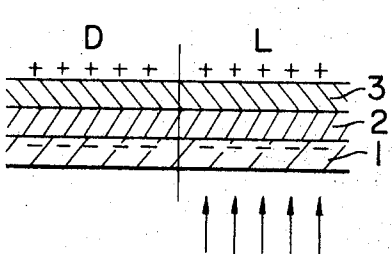


FIG. 3c

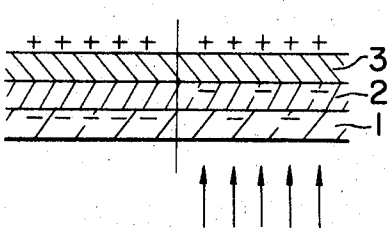


FIG. 3d

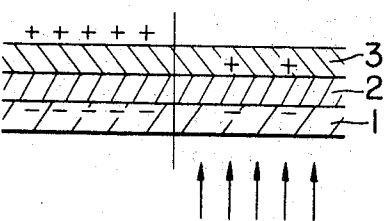


FIG. 3e

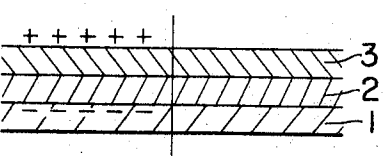


FIG. 4a

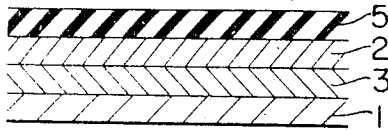


FIG. 4b

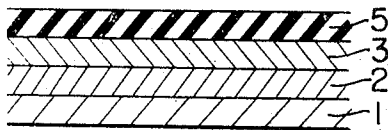


FIG. 4c

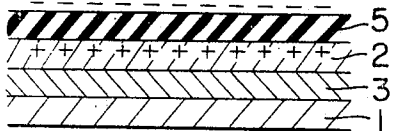


FIG. 4d

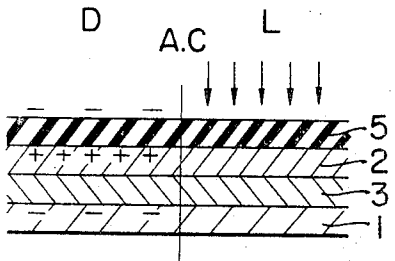


FIG. 4e

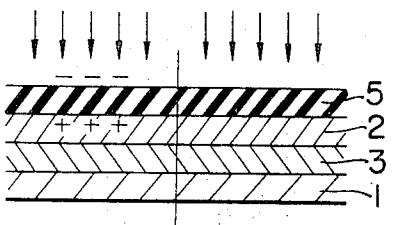


FIG. 4f

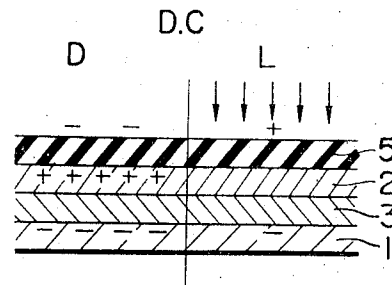


FIG. 4g

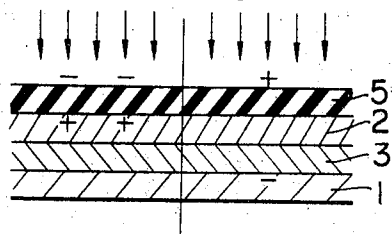


FIG. 5

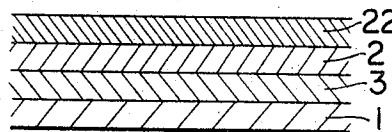


FIG. 6

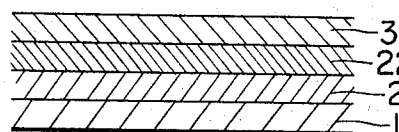


FIG. 7

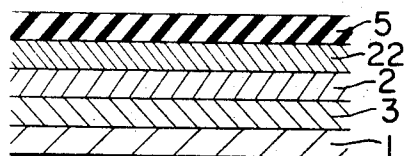


FIG. 8

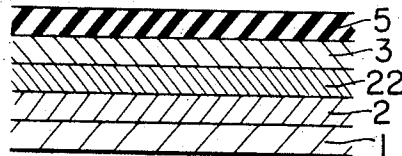


FIG. 9

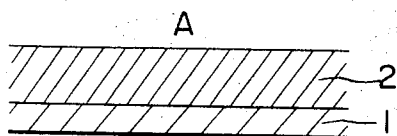


FIG. 10

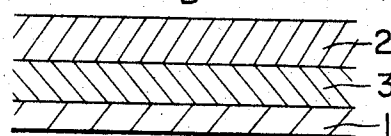
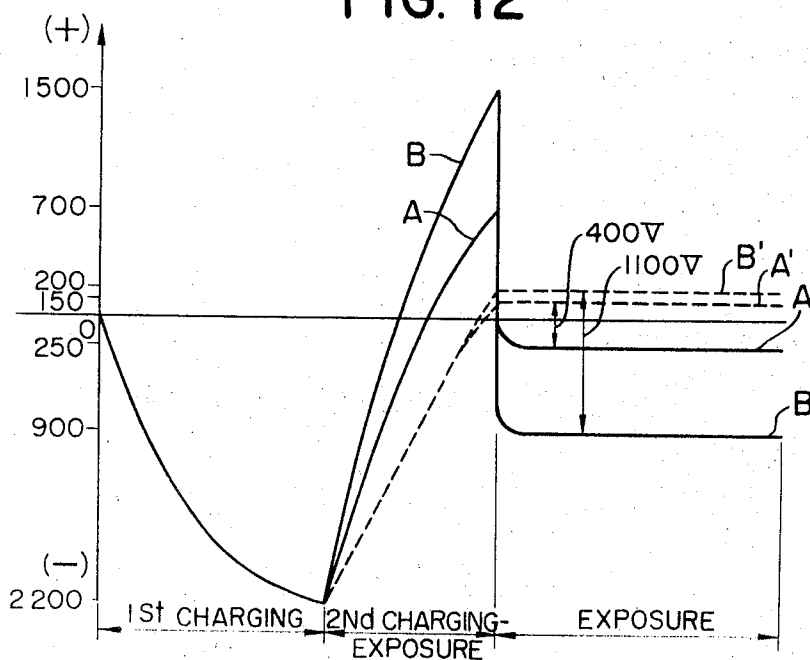


FIG. 12



ELECTROPHOTOGRAPHIC METHOD OF IMAGING WITH AN ELEMENT CONTAINING AN AMORPHOUS SEMICONDUCTOR

This is a continuation of application Ser. No. 43,535, filed June 4, 1970, now abandoned, for "Electrophotographic Photosensitive Member and Electrophotographic Method."

This invention relates to an electrophotographic photosensitive member and an electrophotographic method. More particularly, it relates to an electrophotographic photosensitive member comprising basically a base layer, a photoconductive layer and an amorphous semiconductor layer capable of reversible transition between a highly resistive and conductive state.

Heretofore, electrophotographic methods comprise applying corona charging to a photosensitive member mainly composed of a support and a photoconductive layer and then subjecting to image-wise exposure to form electrostatic images. Another conventional photosensitive layer is composed of an insulating layer laminated to the above-mentioned photosensitive member, and electrostatic images are formed on the insulating layer. In those conventional electrophotographic processes, photoconductivity of the photoconductive layer, that is, electroconductivity appearing upon projecting a light thereto, is utilized. In multicolor reproduction, photosensitive members containing plural number of photoconductive layers for broaden the absorption wave length region, and furthermore the light amount projected to the photosensitive member is apt to be small since the original light image is separated into several colors by using a color separation filter. Therefore, the sensitivity is poor. In general, it is necessary to use a thin photosensitive layer so as to impart sufficient sensitivity with respect to a desired wave length. However, the thinner the photosensitive layer, the lower the dark discharging resistance, and thereby the electrostatic constant is disadvantageously lowered and the clearness of images decreases.

Therefore, an object of this invention is to provide an electrophotographic photosensitive member and an electrophotographic method free from such disadvantages.

Another object of this invention is to provide an electrophotographic photosensitive member capable of giving sharp electrostatic images of high contrast with high sensitivity.

A further object of this invention is to provide an electrophotographic photosensitive member containing an amorphous semiconductor capable of reversible transition between a highly resistive and conductive state.

A still another object of this invention is to provide a photosensitive member having a photoconductive layer of high panchromatic property.

A further understanding of the invention will be presented in the following specification and in the drawings in which:

FIG. 1 is a graph showing a relation between voltage and current of the amorphous semiconductor used in this invention.

FIGS. 2(a) through (e) and FIGS. 3(a) through (e) are enlarged diagrammatic views of formation of electrostatic images according to embodiments of this invention;

FIGS. 4(a) through (g) are an enlarged diagrammatic views of formation of electrostatic images according to another embodiment of this invention;

FIG. 5, FIG. 6, FIG. 7 and FIG. 8 shows various embodiments of photosensitive members according to this invention;

FIG. 9 is an enlarged diagrammatic cross sectional view of a conventional photosensitive member;

FIG. 10 is an enlarged diagrammatic cross sectional view of a photosensitive member containing an amorphous semiconductor layer;

FIG. 11 is a graph showing dark discharging decay of a photosensitive member of this invention and of a conventional photosensitive member; and

FIG. 12 is a graph showing characteristic curve of a photosensitive member of this invention and that of a conventional photosensitive member.

In FIG. 1, there is shown a voltage-current characteristic of an amorphous semiconductor used in this invention. This characteristic depends on a distance between electrodes, atmospheric temperature, and components and composition of the amorphous semiconductor. As far as those factors are kept at the same conditions, the reproducibility of the characteristic is excellent. FIG. 1 is an example for illustrating the characteristic to facilitate understanding thereof. For example, amorphous semiconductors comprising one or more of tellurium, selenium and sulfur, selenium not being used alone, but in combination with tellurium, sulphur or tellurium plus sulphur, one or both of arsenic and antimony and germanium and silicon, or oxides thereof, or As-Te-I system amorphous semiconductors show intrinsic voltage-current characteristic. Referring to FIG. 1, when the voltage V applied to the amorphous semiconductor is gradually increased, a slight conductivity is recognized until the voltage reaches the threshold value V_{TH} , but it is still in an electrically insulating state (volume resistivity — 10^6 to $10^{15} \Omega \cdot \text{cm}$; surface resistivity — 10^8 to $10^{13} \Omega$; and dielectric constant — 3 to 9). When the applied voltage reaches the threshold value V_{TH} , the current abruptly increases and jumps to the point B within 10^{-11} to 10^{-12} sec. and the amorphous semiconductor becomes electrically conductive. The threshold voltage V_{TH} at point A depends on a distance between electrodes, ambient temperatures, components and composition of the amorphous material. As far as these factors are kept under the same condition, the threshold voltage shows the same value with high reproducibility.

When the electric source voltage is rapidly decreased after the working point has jumped to the point B, the working point (current) gradually decreases and reaches a voltage V_H and then return to a point D on 0-A curve and further descends to the original point O along the 0-A curve.

When the electric source voltage is clamped after the working point has jumped to B, the working point begins to move gradually to the point E. When the working point reaches E, the voltage V_{LO} is kept constant and does not vary even if the time lapses. When the electric source voltage is returned to 0, the working point descends from E to 0 in accordance with ohmic state. Then, when the voltage is induced does not go along the 0-A line. The working point can be returned to 0-A line by applying an appropriate pulse voltage or applying a current higher than the current I_{LO} at the point E and rapidly return the voltage to

0. As is clear from the foregoing, the transition between an insulating and conductive state of the amorphous semiconductor can be optionally controlled by adjusting the applied voltage.

Referring to FIG. 2(a) a photosensitive member comprising an electroconductive base 1, an amorphous semiconductor layer 3, and a photoconductor layer 2 is uniformly charged with corona ion of 500 to 3,000V on the photoconductor layer 2 as illustrated in FIG. 2 (b). The polarity is negative when the photoconductive layer 2 is composed of N-type semiconductor, while the polarity is positive when the photoconductive layer 2 is composed of P-type semiconductor. When organic semiconductors are used, most of them have the both types so that any optional polarity may be applied.

In this case, it is necessary to apply a voltage higher than the threshold value. A light image is projected to the photosensitive member by a radiation energy from the photoconductor layer side contemporaneously with or immediately after the charging procedure as illustrated in FIG. 2(c). At the dark portion D not subjected to the radiation energy, the surface charge (positive) and interior charge (negative) are hardly varied since a part of the surface charge (positive) is subjected to dark discharging and reaches the surface of the amorphous semiconductor layer 3, but remains there because the amorphous semiconductor is in an insulating state. In other words, the dark resistance at the dark portion D is larger than that of a conventional photosensitive member comprising a photoconductive layer excluding an amorphous semiconductor and thereby dark discharge is decreased.

At the light portion, electroconductivity of the photoconductive layer 2 increases, and injection of charge (+) occurs to become a state of FIG. 2(c). At this time, if the voltage applied to the amorphous semiconductor layer 3 exceeds the threshold value A to become a conductive state B, the charge state becomes the state as shown in FIGS. 2(d) through (e). In other words, the surface charge (+) is injected through the photoconductive layer 2 and the amorphous semiconductor layer 3 and thereby is dissipated to form electrostatic latent images according to the light and dark portions.

The above-mentioned threshold value A increases with the increase of thickness of the amorphous semiconductor layer 3, for example, several hundreds to several thousands V for 100 μ thickness. The voltage at the conductive state B is several to several tens V. At the dark portion in (a) of FIG. 2, assuming that a voltage applied to the photoconductive layer 2 at the dark portion is V_1 , its capacity C_1 , a voltage applied to the amorphous semiconductor layer 3 V_2 and its capacity C_2 , there is the following relation:

$$C_2/C_1 = V_1/V_2 \quad (1)$$

When a surface area S of the photosensitive member is constant, the following equations are obtained:

$$C_1 = \epsilon_1 (S/d_1) \quad (2)$$

$$C_2 = \epsilon_2 (S/d_2) \quad (3)$$

where ϵ_1 is a dielectric constant of the photoconductive layer 2; d_1 is thickness thereof; ϵ_2 is a dielectric constant of the amorphous semiconductor layer 3; and d_2 is thickness thereof. Substituting formulas (2) and (3) in formula (1), there is obtained the following formula:

$$(\epsilon_2 \times d_1)/(\epsilon_1 \times d_2) = V_1/V_2$$

As is clear from the above formula, the voltage V_2 applied to the amorphous semiconductor layer 2 depends on d_1 , d_2 , ϵ_1 , ϵ_2 and the surface potential ($V_1 + V_2$). Therefore, the voltage V_2 at the dark portion D should be kept lower than the threshold value, for example, by several tens to several hundreds volt by selecting the above-mentioned physical amounts. With respect to the mechanism of injection of electric charge at the above-mentioned light portion L, the conductivity of the photoconductive layer 2 increases and thereby, electric charge reaches the amorphous semiconductor layer 3 and the voltage of the layer 3 increases, and when the value exceeds the threshold value, the state immediately becomes the state of FIG. 2(e). The resistance of the dark portion D is a sum of resistance of the amorphous semiconductor layer 3 and resistance of the photoconductive layer 2 while it is considered that the resistance of the light portion L depends only on the photoconductive layer 2 and the resolving power depends on the thickness of the photoconductive layer composed of photoconductive material. In the present invention, since the amorphous semiconductor layer 3 shows high resistance at dark portions, a photoconductive layer far thinner than conventional one can be used and high sensitivity, high contrast and high resolving power can be obtained. By utilizing conductive state of the amorphous semiconductor layer, an electrolysis developing method also can be employed.

In FIGS. 3(a) through (e), there are shown another embodiment of photosensitive member comprising a base, a photoconductor layer, and an amorphous semiconductor layer and the layers being laminated according to the above order. This photosensitive member also can be used for forming electrostatic images as illustrated in FIGS. 3(a) through (e) by the electrophotographic process similar to that used in FIGS. 2(a) through (e) above. In this case, the base should be conductive.

As a further embodiment of the photosensitive member, there are shown, in FIGS. 4(a) and (b), photosensitive member having an insulating layer 5 composed of organic material such as polyethylene terephthalate and polypropylene, inorganic material such as alumina and mica, or a composite thereof. In FIG. 4(c), a photosensitive member comprising a base 1, an amorphous semiconductor layer 3, a photoconductor layer 2 and an insulating layer 5 laminated according to the above order is given uniformly a negative charge of 500V. to 3,000V. and positive charge is injected from the base (conductive layer) 1 side to the boundary between the insulating layer 5 and the photoconductive layer 2. In this case, the voltage applied to the amorphous semiconductor layer 3 should be higher than the threshold value. As illustrated in FIG. 4(d), there are effected projection of light image contemporaneously with AC corona discharging, and thereby, at the light portion L, the positive charge trapped around the boundary between the insulating layer 5 and the photoconductive layer 2 is discharged to the conductive layer side and simultaneously the negative surface charge is dissi-

pated. On the other hand, at the dark portion D, the resistance of the amorphous semiconductive layer 3 decreases the discharge of positive charge trapped around the boundary between the amorphous semiconductor layer 3 and the photoconductive layer 2. Then, as illustrated in FIG. 4(e), a radiation is projected to the whole surface to reverse the surface potential of the light portion L and the dark portion D and increase the difference of the potential. This electrophotographic process is disclosed in U.S. Ser. No. 571,538 filed Aug. 10, 1966.

According to another electrophotographic process as disclosed in U.S. Ser. No. 563,899 filed July 8, 1966, a primary charge is applied and then exposure is effected contemporaneously with applying secondary charging of a polarity opposite to that of the primary charging as illustrated in FIG. 4(f), and further, a whole surface irradiation is effected as illustrated in FIG. 4(a). Similar processes may be applied to a photosensitive member comprising a base 1, a photoconductor layer 2, an amorphous semiconductor 3 and an insulating layer 5 arranged as illustrated in FIG. 4(b).

Further, utilizing the above-mentioned characteristic of amorphous semiconductors, one or more panchromatic photoconductive layers and a conductive layer are laminated to form a photosensitive member.

When a light image is projected, the light portion absorbs light having wide range of wave lengths and the resistance at the photoconductive layer is low, and therefore, the voltage is applied almost to the amorphous semiconductor layer only, and the voltage switches the amorphous semiconductor layer from the insulating state to the conductive state. At the dark portion, resistance of the photoconductive layer is high and the voltage is divided and applied to the photoconductive layer and the amorphous semiconductor layer so that the voltage is not sufficient to make the amorphous semiconductor layer conductive and the discharge of electric charge can be inhibited by utilizing the insulating state of the amorphous semiconductor layer.

Therefore, according to the present invention, there can be easily obtained a panchromatic characteristic at high sensitivity. Such excellent characteristic can not be obtained by a multicolor electrophotography using a multilayer photosensitive member comprising simply plural photoconductive layers. Further, since discharge at the dark portion can be decreased according to this invention, electrostatic latent images of high contrast can be obtained and further multicolor images can be obtained.

Examples of panchromatic photoconductive layer are shown below.

1. Two or more photoconductive layers having different region of absorption wave length are laminated so as to absorb a light having a certain wave length not absorbed to a layer of image irradiation surface side by using another layer. These photoconductive layers may be made from inorganic materials such as CdS, CdSe, ZnS, ZnO, ZnSe, Se, STe, S, and Se-Te alloy, or organic materials such as anthracene, oxadiazole, imidazolone, acylhydrazone, poly-N-vinylcarbazole, poly-N-vinyl-nitrocarbazole, and polyvinylacridine.
2. An Se-Te alloy layers containing 5 to 10 % Te is used. The Te is added for the purpose of increasing the sensitivity. When the content of Te exceeds 5

%, the resulting alloy becomes panchromatic and has a uniform sensitivity over the whole visible light region. The higher the Te content, the higher the sensitivity. However, when the content exceeds 10 percent, the dark portion discharging resistance decreases, and the characteristic of amorphous semiconductor layer can not be effectively utilized unless other photoconductive layer is laminated thereto. When the content of Te ranges from 5 percent to 10 percent, any other photoconductive layer is not necessary to be laminated.

3. There is used a photoconductive member composed of a panchromatic and highly sensitive photoconductive layer, which is of too low dark resistance to be used for usual electrophotographic methods, overlying said photoconductive layer of high dark resistance. For example, there may be mentioned an Se or Se-Te alloy laminate which comprises one layer containing more than 10 % Te of 0.1 to 20 μ thick and the other layer containing lower than 5 % Te.

In the above cases (1) and (3), the thickness of Se preferably ranges from 0.1 μ to several μ .

FIG. 5 and FIG. 6 illustrates further embodiments of photosensitive member according to this invention. In these figures, the photoconductive layer is composed of two photoconductive layers 2 and 22. The photoconductive layer may be composed of two or more photoconductive layers. The symbols 1, 2 and 3 are the same as in FIG. 2 and FIG. 3. Further, an insulating layer may be provided onto the surface of the photosensitive members in FIG. 5 and FIG. 6. Such photosensitive member having an insulating layer are illustrated, for example, in FIG. 7 and FIG. 8. The previously mentioned electrophotographic processes may be applied to the photosensitive members of FIG. 7 and FIG. 8. The symbols therein are the same as those in FIG. 2 to FIG. 6.

As the insulating layer, there can be used any insulating material capable of permitting a radiation, to which the photosensitive member is sensible, to pass. Therefore, it is not always necessary that the insulating layer is transparent in usual sense. As the base for the photosensitive member, metal, metal foil or a material subjected to a treatment imparting conductivity may be used. When a light image is projected from the base side, the base should permit a radiation energy to be projected to pass.

The following examples are given for illustrating this invention, but by no means for limiting this invention.

Example 1

A photoconductive layer (about 20 μ in thickness) mainly composed of CdS and an amorphous semiconductor layer (about 50 μ in thickness) composed of 45 atom percent tellurium, 32 atom percent arsenic, 12 atom percent silicon, and 11 atom percent germanium were adhered with an adhesive "S dine" (Trade name, supplied by Sekisui Kagaku; polyvinyl chloride). The resulting adhesive layer was about 5 μ in thickness. The laminate thus obtained was placed on and adhered to an aluminum foil (50 μ thick) while keeping the photoconductive layer upward by using an adhesive as mentioned above. Thus, there is obtained a photosensitive member of 120 μ in average total thickness.

The photosensitive member was charged with negative corona ion so that the surface potential at a dark place became 800 V, and contemporaneously a light image was projected to the photosensitive member at 10 lux-sec. The resulting electrostatic contrast between light and dark portions was about 600 V.

A light image having 30 black lines per millimeter was projected to a photosensitive member at the same conditions as above and developed with toner of average 5 μ in particle size to give clear visible images.

Example 2

A photoconductive layer and an amorphous semiconductor layer, each layer having the same composition as corresponding layer in Example 1, were laminated, and the resulting laminate was placed on adhered to a Nesa glass while keeping the amorphous semiconductor layer upward. The resulting photosensitive member gave electrophotographic results similar to those in Example 1.

Example 3

A powder mixture of 60 weight percent Te, 24 weight percent As, 5 weight percent Si, and 10.5 weight percent Ge, each metal being of purity of fine 9 order, was mixed and finely divided for two days with a ball-mill, then placed in a quartz ampoule at a pressure of about 10^{-3} mmHg and the ampoule was sealed. The contents of the ampoule was heated to about 900°C and melted for 20 hours and the ampoule was thrown into water to quench the content, and the glass-like content was taken out. The resulting glass-like product is hereinafter called *a*.

A powder mixture of 85 weight percent Se and 15 weight percent Te was mixed and finely divided for two days and placed in a quartz ampoule at about 10^{-3} mm Hg. and the ampoule was sealed. The content was heated to about 500°C, melted for 10 hours, and then the ampoule was thrown into water and quenched. The resulting glass-like Se-Te alloy was taken out. This Se-Te alloy is hereinafter called *b*.

So powder was placed in a quartz ampoule at a pressure of about 10^{-3} mm Hg. and the ampoule was sealed. The Se powder was heated to about 500°C and melted for 5 hours. Then, the ampoule was thrown into water to take out the resulting glass-like Se. This glass-like Se is hereinafter called *c*.

When preparing *b* and *c*, it is possible to inhibit their crystallization and stabilize them by adding Ge and/or Si.

About 50 g. of *a* was deposited on an aluminum base plate of about 200 μ thick by vacuum evaporation at a pressure of 10^{-4} to 10^{-5} mm Hg. at vapor source temperature of about 600°C while the temperature of the base plate was about 60°C. The resulting amorphous semiconductor layer (hereinafter called "layer-a") was about 50 μ in thickness. The "layer-a" was then coated with *b* of about 15 μ thick by vacuum evaporation (pressure — about 10^{-5} mm Hg.; vapor source temperature — about 250°C; base plate temperature — about 65°C). The resulting Se-Te alloy layer ("layer-b") was the coated with *c* of 1 μ thick by vacuum evaporation (pressure — about 10^{-5} mm Hg.; vapor source temperature — about 250°C; base plate temperature — about 68°C) to produce a photosensitive member.

Then, a negative film having blue, yellow and red lines, each of which is about 0.1 mm. wide, and blue,

yellow and red positive toners were prepared. The photosensitive plate as obtained above was given a positive charge of about 800 V. by a corona discharger and a light of 2 lux-sec. was projected to the photosensitive plate through the negative film which yellow and red lines were covered. The latent image thus formed was developed with a blue toner by a fur brush. Then, blue and red lines were covered and exposure was effected followed by developing with yellow toner. Further, blue and yellow lines were covered to effect exposure followed by developing with red toner. Thus, very clear three-color images were obtained.

Example 4

A polyethylene terephthalate film of about 25 μ thick was adhered to the surface of photosensitive plate obtained in Example 3 with an epoxy resin. The negative film and blue, yellow and red negative toners in Example 3 were also used here.

Negative primary charge was effected and the electrophotographic process disclosed in U.S. Ser. No. 563,899 filed July 8, 1966 was repeated three times to give clear three-color images. The primary charging voltage, the secondary charging voltage and exposure amount were about 1,500 V., 2,000 V., and 2 lux-sec., respectively.

Example 5

A photosensitive member was prepared by depositing the *a*, *b* and *c* obtained in Example 3 on an aluminum base plate of about 200 μ thick by vacuum evaporation. The *a* was firstly deposited on the aluminum base plate to form a layer of about 50 μ thick, and then *c* and *b* were subsequently deposited to form a layer of about 3 μ thick and a layer of about 10 μ thick, respectively. The resulting photosensitive member was subjected to the electrophotographic process as described in Example 3 to give clear three-color images.

Example 6

A photosensitive member obtained by adhering a polyethylene terephthalate film of about 25 μ thick onto the photosensitive member of Example 5 with an epoxy resin was subjected to the electrophotographic process of Example 4 using the negative film and the negative toner to produce clear three-color images.

Example 7

A powder mixture of 92 weight % Se and 8 weight % Te was mixed and finely divided for two days by using a ball-mill and placed in a quartz ampoule at a pressure of about 10^{-3} mm Hg and then the ampoule was sealed. The ampoule was heated to about 500°C, the content was melted for about 10 hours, and then the ampoule was thrown into water to quench, and a glassy Se-Te alloy was taken out. The resulting glassy one is designated as *d*.

The *a* (about 50 g.) obtained in Example 3 was deposited on an aluminum base plate of about 200 μ in thickness by vacuum evaporation (pressure — about 10^{-4} to 10^{-5} mm Hg.; vapor source temperature — about 600°C; and base plate temperature — about 60°C). The resulting amorphous semiconductor layer was about 50 μ in thickness.

The *d* was, then, deposited on the resulting amorphous semiconductor layer (*a* layer) by vacuum evaporation (pressure — about 10^{-5} mm Hg.; vapor source

temperature — about 250°C; base plate temperature — about 68°C). Thus, there is obtained a photosensitive member where the *d* layer is 20 μ thick.

Then, the electrophotographic process in Example 3 using the same negative film and positive toner was applied to the photosensitive member obtained above to give very clear three-color images.

Example 8

A polyethylene terephthalate film of about 25 μ in thickness was adhered to the surface of the photosensitive member as obtained in Example 7 by using an epoxy resin. The resulting photosensitive member was subjected to an electrophotographic process adopted in Example 4 using the same negative film and negative toner to give very clear three-color images.

This invention can produce sharp electrostatic images of high contrast with high sensitivity. This will be further illustrated below. FIG. 9 shows a conventional photosensitive member (A) composed of a base 1 and a Se-Te (Te 15 percent) photoconductive layer 2 of 60 μ in thickness. FIG. 10 shows a photosensitive member (B) according to this invention composed of a base 1, an amorphous semiconductor 3 of 100 μ in thickness, and a photoconductor layer 2 of Se-Te (Te 15 percent) of 30 μ thick. Voltage of about 500 V. is applied to each photosensitive member above and the decay due to dark discharging is shown in FIG. 11. The photosensitive member (B) according to this invention hardly show decay due to dark discharging while the conventional one (A) shows remarkable decay. In practical electrophotographic processes using a drum type photosensitive member, it take about 2 seconds from charging to projection of light image. As is clear from FIG. 11, voltage of the conventional photosensitive member (A) decreases to about 100 V in 2 seconds while the photosensitive member (B) of this invention does not show such remarkable decrease in voltage in 2 seconds and thereby, is very advantageous. It is desirable that the decay when irradiated at illumination of 10 lux after charging is particularly rapid. According to the present invention, conductivity of the photosensitive member becomes high as soon as the voltage applied to the amorphous semiconductor exceeds the threshold value, and as shown by B' in FIG. 11, the decay is effected in a period of time as short as about 0.03 second. On the other hand, about 0.05 second is necessary for the conventional photosensitive member as shown by A' in FIG. 11.

With respect to characteristic of a photosensitive member having an insulating layer on the surface as illustrated in FIG. 4, characteristic of the photosensitive member as illustrated in FIG. 4 is represented by B in FIG. 12 and characteristic of a conventional three-layer structure photosensitive member composed of insulating layer — photoconductive layer — base is represented by A in FIG. 12. For example, a negative charge of 2,200 V is applied to the insulating layer as

a primary charging and then a secondary charge is applied thereto contemporaneously with projection of a light image to give a charge of about +1,500 V to the dark portion in case of B while a charge of about +700 V is given in case of A. After whole surface irradiation, a charge of about -900 V is given in case of B while a charge of about -250 V is given in case of A.

On the other hand, the charge potential at the light portion is represented by B' in case of the photosensitive member of this invention and by A' in case of the conventional one, and they are about +200 V and +150 V, respectively.

Therefore, the contrast between light and dark portions of the resulting electrostatic images is about 1,100 V in the present invention, while it is about 400 V in the conventional one. As is clear from the foregoing, images obtained according to the present invention are advantageously sharp and of high contrast with high sensitivity.

What is claimed is:

1. A method for forming an electrostatic image comprising providing a photosensitive member having a conductive layer, an amorphous semiconductor layer capable of reversible transition between an insulating state and a conductive state and a photoconductive layer, and projecting a light image onto said photosensitive member while contemporaneously applying thereto a voltage exceeding a threshold value of said amorphous semiconductor layer.

2. A method according to claim 1 in which the layers of the photosensitive member are laminated in the sequence of recitation as follows: the conductive layer, the photoconductive layer, and the amorphous semiconductor layer.

3. A method for forming an electrostatic image comprising providing a photosensitive member having a conductive layer, an amorphous semiconductor layer capable of reversible transition between an insulating state and a conductive state, a photoconductive layer and an insulating layer, charging uniformly the photosensitive member, and projecting a light image onto said photosensitive member while contemporaneously applying thereto a voltage exceeding a threshold value of said amorphous semiconductor layer.

4. A method according to claim 3 in which the voltage exceeding a threshold value is DC corona voltage having a polarity opposite to the primary charging.

5. A method according to claim 3 in which the voltage exceeding a threshold value is AC corona voltage.

6. A method according to claim 3 in which the layers of the photosensitive member are laminated in the sequence of recitation as follows: the conductive layer, the photoconductive layer, the amorphous semiconductor layer capable of reversible transition between an insulating state and a conductive state and the insulating layer.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,837,853 Dated September 24, 1974

Inventor(s) TATSUO MASAKI ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 14, "simiconductor" should read
--semiconductor--;

Column 2, lines 63 and 64, "Then, when the voltage is in-does not go along the O-A line" should read --Then, when the voltage is increased, the current increases along the O-E line, but does not go along the O-A line.--;

Column 3, line 33, "At the light portion, should read --At the light portion L,--;

Column 5, lines 18 and 19, "Fig. 4(a)" should read
--Fig. 4(g)--;

Column 7, line 43, "So powder" should read --Se powder--.

Signed and sealed this 14th day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents