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(54) **Process for the production of electrically conducting elements and elements produced thereby**

(57) The invention concerns a process for the production of electrically conducting elements, electrically conducting elements comprising at least one patterned electrically conductive layer fixed to at least one plastic support layer produced by said process and the use of

said electrically conductive elements. These elements may for example be used as heating elements for the windshield of vehicles or as antennas for various applications.

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Description

[0001] The invention concerns a process for the production of electrically conducting elements, electrically conducting elements comprising at least one patterned electrically conductive layer fixed to at least one plastic support layer produced by said process and the use of said electrically conductive elements. These elements may for example be used as heating elements for the windshield of vehicles or as antennas for various applications.

[0002] Heating elements consisting of deposited metallic wires or oxide-based coatings are already known from the state of the art.

[0003] However, these heating elements suffer certain important drawbacks.

[0004] First, for heating elements consisting of metallic wires within laminated glazing problems can arise between the deposition of the wires and the lamination of the glazing, so that once the wires are deposited, the glass pane has to be manipulated extremely carefully to avoid any deformation or destruction of the wires. This is specially required when very thin wires are used.

[0005] Moreover, even very thin wires with a diameter between 25 μm and 50 μm may still be seen by the naked eye.

[0006] On the other hand, heating elements designed as coated layers provide a high transparency but are extremely difficult to obtain because an homogeneous thickness is required over the whole coated surface. Beside of this, the inclusion of air bubbles should also be avoided to get high transparency and an homogeneous heating. Furthermore, once the glass pane is coated it has also to be manipulated very carefully to avoid any damage for example by scratching the coating. Moreover, the formation of cracks and other defects within the coating may reduce both the transparency and the homogeneity of the heating.

[0007] It is therefore an object of the present invention to provide a process for the production of electrically conducting elements and electrically conducting elements produced thereby, which can easily be manipulated, while also allowing a patterning comprising very small lines, so that a high transparency and low visual obstruction may be achieved.

[0008] This is done by the process with the features of claim 1. Other advantageous embodiments of the process are described by the dependent claims 1-23.

[0009] Furthermore, an electrically conducting element with the features of claim 24 is also provided by the present invention. Other advantageous embodiments of the electrically conducting element are described by the dependent claims 25-30.

[0010] The electrically conductive element is preferably produced from at least one electrically conductive layer fixed to at least one plastic support layer.

[0011] In some embodiments of the present invention there may be two or more electrically conductive layers

at least in certain areas. These layers may be of the same or of different materials. Furthermore, these layers may be of the same or of different thicknesses. This may allow to get different resistivity values and therefore for example different heating properties at least in certain areas of the electrically conductive element, to get areas with a faster and/or stronger heating.

[0012] In preferred embodiments of the present invention, the electrically conductive layer may be a metallic layer. The use of a metallic layer allows to reach higher conductivity and lower power consumption during heating. Moreover, metallic layers have good mechanical properties and especially they have a fairly wide elastical deformation range so that they may be deformed, for example bended, in a fairly wide amplitude range without permanent damage for the layer. This may render the handling of both the conductive layer fixed on the plastic support layer and of the final electrically conductive element easier when at least one metallic layer is used.

[0013] The plastic support layer may be a polymeric support layer used to provide the desired good mechanical properties to the electrically conductive element, so that it can be handled easily. The plastic support layers may be fixed only at one side of the electrically conductive layer, so that the etching may be performed from the side, which is free of plastic support layer.

[0014] The plastic support layer may ensure that the electrically conductive layer fixed on the plastic layer may be easily manipulated, preferably for example by rolls, bands, machines or automates, during the production process, preferably including patterning, especially etching, of the electrically conducting element according to the present invention. Beside this the plastic support layer may also ensure that the electrically conducting element comprising the patterned electrically conductive layer is easily handled and stored after its production. As the electrically conductive layer is fixed to the plastic support layer, the plastic support layer helps keeping the desired pattern once it became patterned. Without, fixing both layer together problems may arise after the patterning because depending on the desired pattern and specially when it comprises very small and/or thin lines and/or elements the mechanical properties and the mechanical strength of the electrically conductive layer may decrease strongly. In this case, the fixed plastic support layer dramatically reduces the risk of undesired local distortions of the patterned electrically conductive element, like for example twisting of some lines and/or elements or undesired folding of some lines and/or elements.

[0015] In some preferred embodiments of the present invention, there may be two or more than two plastic support layers at least in certain areas. These layers may be of the same or of different materials. Furthermore, these layers may be of the same or of different thicknesses. This allows to reinforce the plastic support layer at least in certain areas, which may mainly implied during manipulation operations. Using stronger materials and/or thicker layers and/or an increasing number of layers al-

lows to get an increased mechanical resistance in areas, which are particularly stressed during manipulation operations. Moreover more than one plastic support layer may allow to combine the properties of different materials of several layers to get the desired properties, so that for example one layer of a fairly heat resistant material, which might have poor chemical resistance, may be used together with a layer of a material providing good chemical resistance but a poor heat resistance to get the desired properties.

[0016] Furthermore, if at least two plastic support layers are used one may be used to provide good mechanical properties and fair chemical- and heat resistance, while another plastic support layer may be used to provide other properties like for example adhesion enhancing or radiation absorbing/filtrating properties. In this case, one layer may be used as UV- or IR-filter, to protect underlying layers or to reduce the glass house effect or to enhance adherence of the electrically conductive element to substrates or to additional layers like for example glass panes. A plastic support layer providing good mechanical properties and fair chemical- and heat resistance like for example a polyethylene terephthalate (PET) or polyethylene naphthalate (PEN) layer may for example be combined to a polyvinylbutyral (PVB) layer, so that the adhesion of the electrically conductive element to glass panes is enhanced during the lamination for the production of laminated glazing.

[0017] The plastic support layer may be fairly heat resistant, fairly resistant to chemicals and have good mechanical properties. Fairly heat resistant in the sense of the present invention means that it lends itself to stay between glass panes during lamination and the subsequent heat treatment to get laminated glazing. The plastic support layer has thus to be fairly heat resistant to avoid the formation of bubbles or to avoid the deformation of the electrically conductive element by shrinking during the heat treatment performed in the production of laminated glazing.

[0018] Fairly resistant to chemicals in the sense of the present invention means that the plastic support layer has to be resistant to etchants, photosensitive substances and commonly used washing solution (including for example sodium hydroxide solutions) commonly used in photolithographic processes. This allows to enhance the mechanical resistance of the electrically conductive layer during the production process of the electrically conductive element, beside of ensuring an easy handling of the electrically conducting elements after their production.

[0019] Good mechanical properties in the sense of the present invention are given when the plastic support layer does for example not be deformed permanently, form crack or rip during common manipulating operation and/or storing, such for example as the manipulating operation used to incorporate the electrically conducting element into laminated glazing.

[0020] In a preferred embodiment of the present invention the plastic support layer may comprise olefin based

polymers or copolymers, which provide fair heat resistance, fair resistant to chemicals and good mechanical properties. These polymers may further comprise one or more than one additives, which could for example be plasticizers, colorants, antioxidants, UV or IR-absorbing compounds, ...

[0021] These additives allow to increase flexibility, to provide some colours, to increase the stability of the plastic support layer and/or to absorb undesired radiation.

[0022] High flexibility of the plastic support layer may be desired to provide good mechanical properties. A more flexible plastic support layer may perform better, as it is not so prone to rip or form cracks, during manipulating operation as a less flexible one.

[0023] Colours may be desired at least in some areas, for example to avoid blending phenomena. In preferred embodiments, this may be done by providing for example a plastic support layer with a dark coloured stripe preferably at one edge.

[0024] Antioxidants may provide an increased stability of the plastic support layer during time this may be useful for example to keep transparency while aging.

[0025] UV and IR absorbing compounds may be used both for increasing to protection of underlying layers from the corresponding radiation and to reduce the glass-house effect when the electrically conductive element is used in glazing applications.

[0026] In a preferred embodiment of the present invention, the plastic support layer may be at least partially transparent.

[0027] Transparent in the sense of the present invention means that it meets the transparency requirements for car glazing. These requirements may be different from country to country or from region to region depending on national law or regional law.

[0028] Partially transparent in the sense of the present invention means that more than 50%, preferred between 70% to 100%, specially preferred between 80% and 100%, even more preferred between 85% and 95% of the surface area of the electrically conductive element is transparent in the sense of the present invention.

[0029] In a preferred embodiment of the present invention, the plastic support layer may be highly transparent. Highly transparent in the sense of the present invention means that it meets the transparency requirements for windshields. These requirements are particularly high and as the visibility of the car driver has not to be hindered.

[0030] However, transparent in the sense of the present invention may preferably mean having a transmission higher than 50%, preferably higher than 60%, further preferred higher than 70%, specially preferred higher than 80%, further preferred higher than 90% and even further preferred higher than 95% in the visible wavelength range, preferably in the wavelength range from about 380 nm to 750 nm.

[0031] Using an at least partially transparent plastic support layer allows to consider the use of the electrically

conductive elements in/on car glazing.

[0032] In preferred embodiments of the present invention the plastic support layer comprises polyethylene terephthalate (PET) or polyethylene naphthalate (PEN), which provide good mechanical properties and fair heat and chemical resistance, although PEN may provide an increased heat resistance.

[0033] To fix at least one electrically conductive layer at least one plastic support layer, one may partially embed the conductive layer into the plastic support layer or one may glue the electrically conductive layer to the plastic support layer.

[0034] The conductive layer may be at least partially embedded into the plastic support layer for example by laminating these layers together optionally while heating.

[0035] If the electrically conductive layer is glued to the plastic support layer the requirements for the glue are the same as the requirements for the plastic support layer.

[0036] In preferred embodiments of the present invention the glue may be transparent or highly transparent.

[0037] As they meet these requirements, both polyolefin and polyurethane based glues may for example be used in the process according to the present invention.

[0038] In preferred embodiments of the present invention, polyolefin based glues are used as they may have a better chemical resistance and a better long-term stability.

[0039] Moreover, in an even more preferred embodiment of the present invention the glue based on the same material as the plastic support layer. This increases the compatibility of the glue and the plastic support layer and provides a stronger and longer lasting gluing.

[0040] The glue may for example be selected from polyethylene-based glues.

[0041] Furthermore the glue may comprise one or more components with or without at least one additive such as cross-linking agents, viscosity adjusting agents, tackifiers, colorants, antioxidants, UV or IR-absorbing compounds to stronger and/or quicker gluing and/or longer lasting gluing. Furthermore, glues with more than one component may be easier to handle as they work as glues only when at least two components are in contact.

[0042] The process according to the present invention comprises subjecting at least one conductive layer fixed on at least plastic support layer to patterning to obtain at least one patterned electrically conductive layer with the desired pattern.

[0043] The patterning may be performed using a laser or alternatively through a serie of photolithographic steps.

[0044] However, etching the desired pattern allows to very easily obtain complex patterns and/or patterns with very thin elements, for example very thin lines, which may not be obtained by depositing a wire.

[0045] Complex patterns may for example be patterns comprising lines with a varying line width to get different resistivity values and therefore different heating properties, depending on the line width and on the subsequent

resistivity value, for certain areas of the pattern. Using a pattern with different lines widths allows to create different heating zones.

A heating zone may have any form and differs in heating properties and thus for example in resistivity from at least one boarding zone.

[0046] As lasers drain a lot electrical power and patterning using lasers may be relatively slow depending of the complexity of the desired pattern (and thus on the required laser movements), the movement speed of the lasers, the material that has to be patterned. A process using a series of photolithographic steps may preferably be used when a complex pattern and/or a high throughput is desired.

[0047] In preferred embodiments of the present invention, at least one electrically conductive layer fixed on at least one plastic support layer is patterned through a series of photolithographic steps comprising:

- coating the electrically conductive layer with at least one photosensitive substance,
- exposing the substance to electromagnetic radiation in a certain area or in certain areas,
- removing either the non-exposed photosensitive substance(s) or the exposed photosensitive substance(s),
- etching the desired pattern into the metallic layer,
- stripping of the remaining either exposed or non-exposed photosensitive substance(s).

[0048] Optionally there may be a step of subjecting the baking the remaining either exposed or non-exposed photosensitive substance(s) to a heat treatment before the etching and after removing either the non-exposed photosensitive substance(s) or the exposed photosensitive substance(s).

[0049] In preferred embodiments of the present invention, there may optionally be a step stabilising, curing, baking the remaining either exposed or non-exposed photosensitive substance(s) before the etching and after removing either the non-exposed photosensitive substance(s) or the exposed photosensitive substance(s).

[0050] Optionally drying may be performed after each step and specially after coating the electrically conductive layer with at least one photosensitive substance and/or after stripping of the remaining either exposed or non-exposed photosensitive substance(s), using a heat treatment.

[0051] Each of these steps may be done one or repeated more than one time, as it may be useful. They may be performed at different temperatures, to accelerate or to slow down the desired reaction and/or effects. The steps of removing either the non-exposed photosensitive substance(s) or the exposed photosensitive substance(s) or of stripping of the remaining either exposed or non-exposed photosensitive substance(s) may be repeated several times to remove or to strip of the desired

substance, so that no rests are staying.

[0052] A photosensitive substance may be any substance usable or commonly used as photoresistive lacquer in photolithographic processes or variants thereof.

[0053] The photosensitive substance(s) may for example change from a dissolution inhibitor to a dissolution enhancer and/or be weakened and/or degraded by exposition to electromagnetic radiation, so that the weakened and/or degraded and/or dissolved photosensitive substance(s) may be easily removed by washing.

[0054] In preferred embodiments of the present invention, the photosensitive substance(s) may for example be hardened and/or polymerised and/or at least partially cross-linked by exposition to electromagnetic radiation, so that it cannot be removed by a simple washing.

[0055] In even more preferred embodiments of the present invention the photosensitive substance(s) and/or its degradation product(s) may be water soluble. This allows the use of water to remove either the exposed or the non-exposed photosensitive substance, so that the waste treatment is facilitated.

[0056] In other preferred embodiments of the present invention, the photosensitive substance(s) may comprise casein or be casein based, so that waste treatment is further facilitated because casein is a non-toxic product/by-product used/produced in food industry.

[0057] Furthermore, the use of a casein based photosensitive substance allows to remove the photosensitive substance by water and to strip of the hardened photosensitive substance with an aqueous solution, especially a sodium hydroxide solution. This further facilitates the treatment of the production waste.

[0058] In other preferred embodiments of the present invention the photosensitive substance(s) may comprise at least one additive, such as monomers, polymers, to get a solid coating, cross-linking agents, to allow or to increase the cross-linking of the photosensitive substance, so that the photosensitive substance(s) may become harder to removed after exposition to electromagnetic radiation, initiators especially photosensitive initiators, which may for example be cleaved and/or degraded to produce radicals, to initiate the dissolution, the weakening, the degradation or the hardening, the polymerisation and/or the cross-linking of the photosensitive substance(s) upon exposition to electromagnetic radiation, catalysers or inhibitors, to adapt the hardening, polymerising, cross-linking, weakening or degradation speed to the speed of the production process.

[0059] Electromagnetic radiation in the sense of the present invention may be any radiation with a wavelength comprised between 10 m and 10^{-17} m. In preferred embodiments, the wavelength of the radiation may be between 500 nm and 10^{-17} m. In preferred embodiments, the electromagnetic radiation may be UV-radiation. The electromagnetic radiation may therefore have preferably a wavelength comprised between 450 nm and 1 nm and even more preferably between 300 nm and 425 nm. It should be noted that wavelength of the electromagnetic

radiation may also be at least one wavelength range within the previously cited ranges or comprise at least one or preferably two distinct wavelengths within the cited ranges.

[0060] To expose at least certain areas to electromagnetic radiation, while selecting the exposed and the non-exposed areas the source of electromagnetic radiation is placed behind a mask, which may stop the radiation at least in some areas.

[0061] The mask may be produced by any process usable or commonly used for the production of mask in photolithographic processes. The mask should be patterned, so that the desired areas may be exposed to electromagnetic radiation to get the desired pattern for the electrically conductive layer.

[0062] In preferred embodiment of the present invention, the mask may be a photo glass plate, comprising a photo-sensitive emulsion with extremely fine silver halide crystals to obtain very high resolution. It may be covered for example with a gelatine protection layer. The photo glass plate may for example be patterned by contact exposure in a printer equipped for example with a mercury or xenon lamp. After exposure, the photo glass plate is developed, so that the transparency of the emulsion and/or of the underlying is reduced for example by preferably depositing silver at least in certain exposed areas to get the mask with the desired pattern for the electrically conductive layer. The non-exposed emulsion and/or the underlying glass plate may preferably have a transmission value of more than 50% in the wavelength range of the electromagnetic radiation.

[0063] In some even more preferred embodiments of the present invention, the photo glass plate may be patterned by direct imaging using for example a photoplotter equipped with a preferably high power laser, to allow high precision and patterns comprising very small lines.

[0064] The exposition to electromagnetic radiation may be performed in conditions, so that the photosensitive substance(s) is/are either changed from a dissolution inhibitor to a dissolution enhancer and/or weakened and/or degraded or hardened and/or polymerised and/or at least partially cross-linked at least in certain areas according to the desired pattern.

[0065] The exposition to electromagnetic radiation may be performed for example during between 0.1 and 5 minutes, preferred 0.1 and 1 minutes, specially preferred between 5 and 40 seconds.

[0066] The temperature during the production process may be in the range between 10 and 30 °C, preferred 20 and 25 °C, specially preferred 22 and 24 °C.

[0067] After the exposition to electromagnetic radiation, either the non-exposed photosensitive substance(s) or the exposed photosensitive substance(s) may be removed.

[0068] In the case the exposed photosensitive substance(s), which means the photosensitive substance(s) which was/were exposed the electromagnetic radiation, may be removed the photolithographic process is called

positive.

[0069] On the other hand, if the non-exposed photosensitive substance(s), which means the photosensitive substance(s) which was/were not exposed the electromagnetic radiation, may be removed the photolithographic process is called negative.

[0070] Using a negative photolithographic process requires to use a so-called darkfield mask, where only the elements of the pattern like for example the lines or apertures are transparent.

[0071] Using a positive photolithographic process requires to use a photosensitive substance that may be changed from a dissolution inhibitor to a dissolution enhancer or a hard or previously hardened photosensitive substance(s) which is/are weakened and/or degraded by exposition to electromagnetic radiation.

[0072] However, in this case one can not use a darkfield mask but needs to apply a mask with very small non-transparent lines. This means that areas, which should not be exposed, may also become at least partially exposed to the electromagnetic radiation. This hinders to obtain of the desired pattern for the electrically conductive layer.

[0073] After the exposition to electromagnetic radiation, the photosensitive substance may be removed from the exposed areas and these areas may be subsequently etched.

[0074] Using a negative photolithographic process requires to use a photosensitive substance which is hardened and/or polymerised and/or at least partially cross-linked by exposition to electromagnetic radiation. Moreover using a negative photolithographic process allows to easily realise patterns comprising even very thin lines as the electromagnetic radiation, has in this case only to pass through slits or apertures because the photosensitive substance may be removed from the non-exposed areas, which may then be subsequently etched. This reduces the risk of exposing undesired areas to the electromagnetic radiation.

[0075] This means that if very thin lines are desired a negative photolithographic process is preferred because to obtain the thin lines one has not to expose very large areas corresponding to the surrounding of the lines to electromagnetic radiation to remove the photosensitive substance(s) in the exposed areas before etching like in a positive photolithographic process, where the exposure of the entire area except for the thin lines may very easily lead to over-exposure, meaning that the lines themselves may be at least also partially exposed, avoiding to obtain the desired pattern.

[0076] Using a negative photolithographic process allows thus to expose only the lines themselves and to remove the photosensitive substance in the non-exposed areas before etching, to get a high precision even when complex patterns and/or pattern comprising thin and/or small lines and/or other thin and/or small lines elements are desired.

[0077] However, either the exposed or the non-ex-

posed photosensitive substance may be removed by washing.

[0078] The washing may be performed with any solution which solubilises at least partially the photosensitive substance(s) or it's weakened form or it's degradation product(s) without removing the hardened and/or polymerised and/or cross-linked form of the photosensitive substance. This solution may be water, aqueous solution, any organic solvent or mixtures thereof.

[0079] In preferred embodiment, the washing may be performed with water or aqueous solutions, which allows to facilitate the waste treatment of the production process. The waste treatment is even more facilitated when water is used.

[0080] Additionally, using water or aqueous solutions, may have less influence on the plastic support layer in to the use of organic solvents.

[0081] The patterning of the electrically conductive layer is done by etching the desired pattern into the electrically conductive layer using an etchant, which may be any compound, solution, gas or mixture, which is able to degrade the electrically conductive layer.

[0082] For the etching, each etchant usable or commonly used for photolithographic processes and variants thereof may be used for etching the electrically conductive layer.

[0083] In preferred embodiment of the present invention, the etchant may be an acid, preferably a Lewis acid, even more preferably an aqueous basic solution. In other preferred embodiments of the present invention, the etchant may be a base, preferably a Lewis base, even more preferably an aqueous basic solution.

[0084] In even more preferred embodiments of the present invention the etchant may be a chloride, especially preferred ferric or cupric chloride or a persulfate, especially preferred for ammonium persulfate or solution thereof, preferably aqueous solutions.

[0085] In even more preferred embodiments of the present invention, more than one etchant may be used to perform the etching. This may preferably be done when several electrically conductive layers of different materials are used, so that and appropriate etchant for each electrically conductive layer may be used. Moreover, the etching may be performed in one or more than one etching step, so that the same etchant may be applied several times or that different etchant may be applied one after another.

[0086] The remaining either exposed or non-exposed photosensitive substance in it's hardened and/or polymerised and/or at least partially cross-linked form may be stripped of after the etching.

[0087] In a preferred embodiment of the present invention either the exposed or the non-exposed photosensitive substance in it's hardened and/or polymerised and/or at least partially cross-linked form may be stripped of by washing.

[0088] The stripping of may be performed with any compound which solubilises and/or weakens and/or de-

grades at least partially the hardened and/or polymerised and/or at least partially cross-linked photosensitive substance. This compound may be water, an aqueous solution, any organic solvent or mixtures thereof.

[0089] In preferred embodiment, the washing may be performed with water or aqueous solutions, especially basic or acidic solutions like for example a sodium hydroxide solution, which allows to facilitate the waste treatment of the production process. The waste treatment is even more facilitated when water is used.

[0090] The pattern selected for the electrically conducting layer may be of any desired shape and comprise lines and other elements. Lines in the sense of the present invention comprise straight lines, curved lines, loops or lines with a meander-like form, especially preferred lines with sinusoidal or cosinusoidal form.

[0091] In a preferred embodiment of the present invention the pattern comprise provide at least one electrical contact of any desired size and shape. This may be required, when the electrically conductive element is used for example as an antenna, to connect senders and/or receptors.

[0092] An electrical contact in the sense of the present invention may be preferably a non-patterned area of the electrically conductive layer of any size or shape, which lends itself to establish an electrical connection to the electrically conductive element.

[0093] In some other preferred embodiment of the invention, the pattern provides at least two different electrical contacts. This may be useful for example, when both receptors and senders have to be connected to an electrically conductive element used as antenna or when the pattern comprises two antennas, which require to different electrical contacts to connect senders and/or receptors.

[0094] In even more preferred embodiments of the present invention, the patterned electrically conductive layer provides an electrically conductive pathway between at least two different electrical contacts. This allows electricity to flow from one electrical contact to the other(s) through the electrically conductive layer. This may for example be desirable when the electrically conductive element is used as heating element.

[0095] The resistance depends in this case of the length (or on the mean length) of the pathway between the two electrical contacts, the thickness of the electrically conductive layer and on the material used as electrically conductive layer.

[0096] In a preferred embodiment of the present invention the electrically conductive element are at least partially transparent. Partially transparent in the sense of the present invention means that more than 50%, preferred between 70% to 100% and specially preferred between 80% and 100% of the surface area of the electrically conductive element is transparent in the sense of the present invention. This allows to use the electrically conductive element for example as heating element or as antenna in or on car glazing.

[0097] Each electrically conductive layer may have a thickness between 5 μm and 200 μm . Increasing the thickness may increase the mechanical resistance of the layer and of the whole electrically conductive element. On the other hand, a layer with an increased thickness may be visually more obstructive than a thinner layer after patterning. The thickness of the electrically conductive layer may therefore preferably be between 7,5 μm and 100 μm , specially preferred between 7,5 μm and 50 μm and even more preferred between 7,5 and 20 μm . Electrically conducting layers with a thickness higher than for example 50 μm may lead to patterned electrically conducting layers which are visually to obstructive for certain applications.

[0098] In some preferred embodiments of the present invention, the thickness of each electrically conductive layer may vary at least in certain areas, so that zones with different resistivities and thus different heating properties may be formed.

[0099] In preferred embodiments of the present invention, the electrically conductive layer may be a metallic layer.

[0100] In even further preferred embodiment of the present invention the electrically conductive layer may comprise at least, one metal selected from: gold, silver, tungsten, copper, aluminium, a metal alloy like for example steel or an iron-nickel alloy. These metals are specially preferred because of their low resistivity combined with a good mechanical resistance. The resistivity of silver, copper, gold, aluminium and tungsten is specially low. This may be desirable when the use of the electrically conducting element as heating element is intended to provide strong heating with low applied tension. Moreover copper, aluminium and tungsten have specially good mechanical properties, so that the mechanical resistance of very thin and/or small elements may be increased using this metals, to avoid problems during manipulation operations. Moreover, tungsten is very heat resistant, so that high temperatures may be reached during the use as heating element even thin lines or small elements, without the risk of melting.

[0101] In a preferred embodiment of the present invention, each plastic support layer has a thickness between 10 μm and 1000 μm , preferred between 10 μm and 500 μm , specially preferred between 25 μm and 250 μm and even more preferred between 40 μm and 150 μm . An increased thickness of the plastic support layer provides a better mechanical resistance, thereby avoiding problems during manipulation operation. On the other hand, an increased thickness of the plastic support layer may become a problem when certain applications are intended. When the use of the electrically conductive element as heating element within a laminated glazing is intended, a thick plastic support layer may lead to the formation of a plastic material bulging at the border of the glass pane during lamination. This border has to be removed in an additional production step, when this is too big.

[0102] In some preferred embodiments of the present

invention, the thickness of each plastic support layer may vary at least in certain areas, so that for example areas which are particularly stressed during handling operation may be reinforced using a higher plastic support layer thickness.

[0103] In preferred embodiment of the present invention the patterned electrically conductive layer obtained by the process comprises lines or other elements with a width between 3 μm and 40 μm , preferred between 3 μm and 25 μm specially preferred between 3 μm and 15 μm , even more preferred between 5 μm and 15 μm , further preferred between 7,5 μm and 12,5 μm and even further preferred between 8 μm and 12 μm .

[0104] Using smaller widths allows to obtain a less visually obstructive electrically conductive element and helps achieving transparency. However, using small widths increases the risk of breaking elements and/or lines during manipulation operations and/or during the etching.

[0105] However, lines and/or elements, which are smaller and/or thinner than 15 μm , cannot be seen anymore by the naked eye even from a distance of less than 1 m preferably less than 60 cm, because of the limited resolution of the human eye. Using such elements permit to get really low visual obstruction and transparency or high transparency. Moreover, using lines and/or elements, which are smaller and/or thinner than 3 μm , may cause problems because of the limited accuracy of the etching process, limited to an accuracy of about 2 μm , preferably 1 μm . Using thinner and/or lines and/or elements may lead to interrupted lines and/or elements after the etching process.

[0106] In preferred embodiments of the present invention, the patterned electrically conductive layer obtained by the process according to the present invention comprises lines or other elements that may be blacked in an additional step of the production process, so that they become visually less obstructive, as they are not so easily seen. The lines or elements may for example be blacked using pigments, colours or by oxidation.

[0107] Furthermore, at least one additional layer may be added using an additional step of the production process. These additional layers may be added on both sides of the electrically conductive element. They may be glued to the electrically conductive element or fixed to it by lamination optionally while heating. The additional layer may for example be at least one PVB layer, to promote the adherence of the electrically conductive element to other layers during lamination, or at least one UV- or IR-filtering layer, to avoid protect underlying layers and to reduce the hot house effect, or at least one glass pane, to use the electrically conducting element for example as antenna and/or as heating element in or on glazing.

[0108] The process according to the present invention is thus particularly safe, simple and economic.

[0109] Moreover, the present invention also concerns electrically conductive elements, which are produced by the process according to the present invention. The elec-

trically conductive elements according to the present invention may therefore comprise all the features arising from this process described here before.

[0110] In preferred embodiments, the electrically conductive element comprises at least one plastic support layer fixed to at least one patterned electrically conductive layer comprising lines with a line width between 5 μm and 15 μm . This allows to combine a patterning comprising very thin lines, so that high transparency and low visual obstruction may be achieved, and good mechanical properties, so that the electrically conducting element may easily be manipulated.

[0111] In other preferred embodiments, the electrically conductive element comprises at least one preferably two distinct electrical contacts which were obtained from the electrically conductive layer while patterning it, preferably by etching.

[0112] In even more preferred embodiments of the electrically conductive element according to the present invention, the electrically conductive element is at least partially transparent and preferably highly transparent.

[0113] Finally, the present invention concerns the use of the electrically conductive elements according to the present invention on glazing or within laminated glazing. The electrically conductive elements may be glued or laminated on glazing.

[0114] Within laminated glazing means between two panes of glass.

[0115] In preferred embodiments of the invention, electrically conductive elements are used combined to at least one PVB sheet and two glass panes to produce laminated glazing.

[0116] The electrically conductive elements may thereby be used as antennas and/or or as heating elements within the glazing.

[0117] The glazing which may be heated or become equipped with an antenna using the electrically conductive element according to the present invention may for example be vehicle glazing, specially car glazing including windshields or the glazing the other vehicles like aircrafts, ships, space shuttles, ...

[0118] Moreover, exterior glazing elements used for example for claddings may be heated or equipped with an antenna using the electrically conductive element according to the present invention.

[0119] Finally glazing elements for the interior applications, may be heated or equipped with an antenna using the electrically conductive element according to the present invention to get transparent elements, which may replace classical radiators, or classical antennas.

Example:

[0120] According to the present invention a for example 13 μm thick copper layer fixed to a for example 100 μm thick PET support layer by for example a PET based glue may be used as starting material for the process according to the present invention.

[0121] The copper layer is then coated with a casein based photosensitive substance with a thickness of for example 4-5 μm . By flowing or spraying the photosensitive substance on the copper layer. As the copper layer fixed to the PET is hanging vertically, the substance is constantly removed by the action of the gravity, so that only a thin preferably homogeneous film of photosensitive substance remains on the copper layer.

[0122] After drying the photosensitive substance coating for example between 20 and 40 seconds for example at 70 °C, the coating is exposed through a mask to UV-light with a wavelength in the range of for example between 360 and 420 nm.

[0123] The desired patent comprises two parallel rectangular shaped electrical contacts with a length of one meter and a height of for example 2 cm at a distance of for example 50 cm linked one to another by for example 100 lines with a line width of 10 μm and sinusoidal form. The distance between two sinusoidal lines is approximately of for example 1 cm.

[0124] The mask is designed for a negative photolithographic process, so that that the UV-light is passed through the mask in the areas corresponding to the electrical contacts and the sinusoidal lines. All the other areas are exposed to the UV-light during for example 30 seconds at for example 23 °C and cured in an oven for example 2 minutes at for example 220 °C, so that the casein based photosensitive substance hardens in this areas. This means the casein based substance may no more be removed by a washing with water in the exposed areas.

[0125] After that the casein based photosensitive substance, is removed from the non-exposed areas by washing with water. Water is therefore sprayed on the vertically hanging copper layer fixed to the PET layer. As the copper layer fixed to the PET layer is hanging vertically the water and the casein based photosensitive substance of the non-exposed areas is removed by the action of the gravity, so that the coating of the hardened casein based photosensitive substance remains only in the areas which where exposed to UV-light.

[0126] Ferric chloride is then used as the etchant. The etching is performed by spraying a solution of ferric chloride (for example 1.510 kg/l) during for example 3-4 minutes at for example 35-45 °C on a horizontally transported or vertically hanging copper layer fixed to the PET layer. As the copper layer fixed to the PET layer is positioned horizontally with the copper layer faced down or as copper layer fixed to the PET layer is hanging vertically the ferric chloride solution is constantly removed by the action of the gravity, so that the etching takes place only where the copper layer is not protected by the hardened coating of the casein based photosensitive substance (in the areas which where not exposed to UV-light). By the etching the electrically conductive layer is completely removed from the plastic support layer, to get a patterned electrically conductive layer with the desired pattern.

[0127] Finally, the hardened casein based photosen-

sitive substance is removed from the copper layer fixed on the PET layer by spraying an aqueous solution of for example 3% sodium hydroxide on it during for example 2-4 minutes at for example 65 °C, to obtain the electrically conductive element according to the present invention.

[0128] The finally obtained element is then dried with infrared elements.

10 Claims

1. Process for the production of electrically conductive elements,
characterised in that, at least one electrically conductive layer fixed on at least one plastic support layer is patterned.
2. Process for the production of electrically conductive elements according to claim 1,
characterised in that, the patterning is done using a laser.
3. Process for the production of electrically conductive elements to one or both of the claims one or two,
characterised in that, the electrically conductive layer is a metallic layer.
4. Process for the production of electrically conductive elements according to one or both of the claims one or three,
characterised in that, the patterning is done through a series of photolithographic steps comprising:
 - coating the electrically conductive layer with at least one photosensitive substance,
 - exposing the substance to electromagnetic radiation in a certain area or in certain areas,
 - removing either the non-exposed photosensitive substance or the exposed photosensitive substance,
 - etching the desired pattern into the electrically conductive layer,
 - stripping of the remaining either exposed or non-exposed photosensitive substance(s).
5. Process for the production of electrically conductive elements according to one or more then one of the claims 1-4,
characterised in that, the patterned electrically conductive layer provides an electrically conductive pathway between at least two different electrical contacts.
6. Process for the production of electrically conductive elements according to one or more then one of the claims 1-5,
characterised in that, the plastic support layer is

at least partially transparent.

7. Process for the production of electrically conductive elements according to one or more then one of the claims 1-6,
characterised in that, an electrically conductive layer has a thickness between 5 μm and 200 μm .
8. Process for the production of electrically conductive elements according to one or more then one of the claims 1-7,
characterised in that, the electrically conductive layer comprises a metal selected: gold, silver, tungsten, copper, aluminium, steel or an iron-nickel alloy.
9. Process for the production of electrically conductive elements according to one or more then one of the claims 1-8,
characterised in that, the plastic support layer provides good mechanical properties, transparency and fair heat- and chemical resistance.
10. Process for the production of electrically conductive elements according to one or more then one of the claims 1-9,
characterised in that, the plastic support layer has a thickness between 10 μm and 1000 μm .
11. Process for the production of electrically conductive elements according to one or more then one of the claims 1-10,
characterised in that, the plastic support layer is glued to the electrically conductive layer.
12. Process for the production of electrically conductive elements according to claim 11,
characterised in that, the glue is a polyester or a polyurethane based glue.
13. Process for the production of electrically conductive elements according to one or more then one of the claims 1-12,
characterised in that, the plastic support layer is selected from PET and PEN.
14. Process for the production of electrically conductive elements according to one or more then one of the claims 1-13,
characterised in that, the photosensitive substance comprises casein.
15. Process for the production of electrically conductive elements according to one or more then one of the claims 1-4,
characterised in that, the electromagnetic radiation has a wavelength between 10 m and 10^{-17} m.
16. Process for the production of electrically conductive

elements according to one or more then one of the claims 1-15,
characterised in that, the exposed photosensitive substance is removed.

17. Process for the production of electrically conductive elements according to one or more then one of the claims 1-15,
characterised in that, the non-exposed photosensitive substance is removed.
18. Process for the production of electrically conductive elements according to one or more then one of the claims 1-17,
characterised in that, the etchant is an acid.
19. Process for the production of electrically conductive elements according to one or more then one of the claims 1-18,
characterised in that, the etchant is selected from chlorides or persulfates.
20. Process for the production of electrically conductive elements according to one or more then one of the claims 1-19,
characterised in that, the etchant is selected from a ferric or cupric chloride or ammonium persulfate.
21. Process for the production of electrically conductive elements according to one or more then one of the claims 1-20,
characterised in that, the remaining either exposed or non-exposed photosensitive substance is stripped of using a organic solvent.
22. Process for the production of electrically conductive elements according to one or more then one of the claims 1-20,
characterised in that, the remaining either exposed or non-exposed photosensitive substance is stripped of using a sodium hydroxide solution.
23. Process for the production of electrically conductive elements according to one or more then one of the claims 1-22,
characterised in that, patterned electrically conductive layer obtained by the process
24. Electrically conductive element,
characterised in that, it is produced by a process according to one or more then one of the claims 1 to 23.
25. Electrically conductive element according to claim 24,
characterised in that, it comprises at least one plastic support layer fixed to at least one patterned electrically conductive layer comprising lines with a

line width between 5 μm and 15 μm .

26. Electrically conductive element according to one or both of the claims 24 and 25,
characterised in that, at least one patterned electrically conductive layer provides an electrically conducting pathway between at least two different electrical contacts. 5
27. Process for the production of electrically conductive elements according to one or more then one of the claims 24-26,
characterised in that, it is at least partially transparent. 10
28. Electrically conductive element to one or more then one of the claims 24-27,
characterised in that, it comprises blacked lines and/or elements. 15
29. Electrically conductive element to one or more then one of the claims 24-28,
characterised in that, it may comprise at least one PVB layer. 20
30. Electrically conductive element to one or more then one of the claims 24-29,
characterised in that, it may comprise at least one glass pane. 25
31. Use of an electrically conducting element according to one or more then one of the claims 24-30,
characterised in that, the electrically conductive element is used as antenna or as heating element on glazing or within laminated glazing. 30
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EUROPEAN SEARCH REPORT

Application Number
EP 06 02 0687

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 96/24963 A (MEGAWAVE) 15 August 1996 (1996-08-15) * page 16, line 20 - line 24 * * page 16, line 28 - line 35; claims 19-21; figure 8 * -----	1-31	INV. H05B3/84 H05B3/86
			TECHNICAL FIELDS SEARCHED (IPC) H05B H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 15 November 2007	Examiner TACCOEN, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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