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Description

Method for engraving images by means of radiation into a radiation-sensitive layer, in particular for laser engraving

The invention relates to a method for engraving images by means of radiation into a radiation-sensitive layer, in particular for laser engraving, according to the preamble of Claim 1.

The engraving of images, for example of passport photographs, signatures, graphical patterns that increase security against forgery, and the like, by means of radiation, in particular by means of laser radiation, into a radiation-sensitive layer is already used to a large extent nowadays in the production of identity cards and papers, such as for example credit cards, bank cards, cash payment cards, personal identity cards, driving licences and passports. For laser engraving or laser inscription, the identity cards or the pages of passports that are to be inscribed are provided with a layer that is suitable for laser engraving, for example a film that is sensitized by special additives, or a coating layer that is sensitive to the radiation used, with the result that an optical and/or haptic change in the layer can be produced by irradiating the radiation-sensitive layer, which change is consistently referred to as blackening in the following text.

In order to engrave an image, that is to say for example a portrait photograph, writing of whatever configuration, or else a relief in the layer, the layer is scanned in a point-by-point manner with a laser beam, the radiation energy or quantity impinging on each dot being set in such a way that a desired blackening is obtained. In order to engrave in particular high-quality portrait photographs into a radiation-sensitive layer, it is necessary that the radiation energy for each dot can be set so accurately that 64, 128 or even 256 grey levels can be obtained.

For this, it is necessary that the laser used have not only a high power, in particular pulse power, but also high temporal stability, in other words that

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the laser beam intensity or the pulse height is constant even over a long time.

However, these high requirements made of the laser make a corresponding laser inscription station relatively expensive, with the result that it is viable only where very large quantities of types of identity cards have to be produced.

Taking this as a departure point, the invention is based on the object of providing a method of the type mentioned in the introduction which enables images to be engraved with high quality and precision into a radiation-sensitive layer without a highly stable radiation source being necessary for this.

This object is achieved by means of the method according to Claim 1. Advantageous refinements of the invention are described in the subclaims.

Thus, the invention provides for the blackening obtained in each dot to be determined and, during the subsequent irradiation of dots, for the radiation energy to be set as a function of sought and obtained blackening.

Thus, while the image is being engraved point by point, the blackening obtained at the respective dots is compared with the blackening sought, for which the radiation energy was set, in order to form a correction value from the blackening sought and the blackening obtained, which correction value is then taken into account in subsequent irradiation processes. What is achieved in this way is that even when the beam intensity of the laser or the pulse height thereof is subject to fluctuations, it is possible to engrave images with high accuracy and precision into the radiation-sensitive layer.

An advantageous refinement of the invention is distinguished by the fact that in a first irradiation pass of each dot, irradiation is effected with a radiation energy that is reduced in a defined manner, with the result that the blackening sought in each dot corresponds to a predeterminable fraction of the

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predetermined blackening for this dot, that the blackening obtained in each dot is determined, and that in at least one further irradiation pass of each dot, irradiation is effected with a radiation energy which is set in accordance with the difference between the blackening already obtained and the blackening sought in this pass.

In this way, blackening faults attributable to statistical fluctuations or temporal drifting of the laser power or the laser beam intensity can be reduced to such an extent that they are no longer perceptible. Even if the relative blackening fault is comparatively high during each irradiation pass, the relative blackening fault for the overall blackening to be obtained in a dot can nonetheless be made very small, in particular if only slight additional irradiation is demanded in the last irradiation pass.

The fundamental concept of the present invention consists, therefore, in detecting the blackening obtained during the engraving or writing of information into a layer by means of radiation, in particular by means of laser radiation, for the individual dots and comparing it with the blackening sought, in order, during the subsequent irradiation of dots, to take account of the previously obtained blackening result when setting the radiation energy in accordance with the blackening to be obtained, with the result that the desired blackening and hence the desired image quality can be achieved with high precision even when relatively simple lasers are used. Furthermore, the double or multiple irradiation additionally has the advantage that laser systems having a substantially lower output power can be used.

In a particularly advantageous refinement of the invention, it is provided that in all of the irradiation passes except for the last, the radiation energy is set in such a way that the blackening additionally sought in the respective irradiation pass corresponds to the same fraction of the difference

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between the present blackening and the predetermined blackening for the respective dot, and that in the last irradiation pass, the radiation energy is set in such a way that the predetermined blackening for the respective dot is sought.

By virtue of the iterative method, the difference between the present blackening and the predetermined blackening for the respective dot can very rapidly be made so small that the blackening fault occurring in the last irradiation pass becomes so small that it is no longer perceptible.

It is particularly advantageous, however, if in the last irradiation pass, the additional blackening sought corresponds to a luminosity difference below the perceptibility limit of the human eye.

In an advantageous refinement of the invention, it is provided that in order to determine the blackening respectively obtained for each dot, the quantity of radiation that is radiated for the said dot is determined.

In this case, it is particularly advantageous if laser radiation is used for the irradiation, and if the blackening obtained in each dot is determined from the respective radiation power. Detecting the radiation power respectively used during the irradiation of a dot is especially well suited to the purpose of acquiring a measure of the blackening obtained, since the irradiation that is necessary for a specific blackening is preferably likewise regulated by way of the radiation power.

In a particularly preferred exemplary embodiment of the invention, it is accordingly provided that in order to generate the laser radiation, a laser system operating in a pulsed mode is used and the blackening obtained in each dot is determined from the pulse height of the laser pulse radiated for the respective dot.

In another refinement of the invention, it is provided that during the laser engraving, the

radiation-sensitive layer to be blackened is imaged onto a photoreceiver arrangement in order to determine the blackening obtained at the individual dots from the luminosity values before and after an irradiation in which case a video camera is expediently used for determining the blackening, the video signals of which video camera are fed to an evaluation circuit in a control apparatus.

Exemplary embodiments of the invention are explained in more detail below with reference to the drawing. The single figure of the drawing shows a schematic block diagram of a laser engraving installation for carrying out the method according to the invention.

As illustrated in the drawing, the laser engraving or inscription installation has a laser system 10, a shutter device 11 and a beam deflection device 12. A laser beam 13 generated by the laser system 10 passes through the shutter device 11, which may be an acousto-optical switching diaphragm for example, to the beam deflection device 12, which deflects the laser beam 13 in the x- and y-direction in such a way that a writing beam 13' scans an image plane B in a point-by-point manner.

A control apparatus 14 controls the shutter device 11 and the beam deflection device 12 in a manner such that the radiation energy impinging on each dot $P_{k,l}$ of a radiation-sensitive layer is large enough for a specific blackening to be achieved in the dot.

Instead of a shutter device 11 that is separate from the laser system 10, the laser-beam exit window of the laser system 10 may also be used for setting the beam power. If, by way of example, a continuously pumped laser, in particular a neodymium-YAG laser, is used in order to generate appropriate laser pulses for irradiating the radiation-sensitive layer, then the transmittance of the exit window can be varied individually for each individual irradiation process, in order to set the pulse height of each laser pulse.

In this case, the transmittance of the exit window can be set so accurately for each pulse that up to 256 grey levels or more can be produced.

In order to determine the blackening obtained by a respective irradiation process, a pulse height sensor 15 is provided, which receives a small part of the pulse energy via a weak splitter mirror 16 and which supplies an output signal corresponding to the pulse height of each laser pulse to the control apparatus 14. The pulse height detected is in a fixed relationship with the blackening achieved, depending on the photosensitive material used and the laser system used. This relationship can be determined by means of a suitable calibration run and is required for controlling the individual irradiation processes.

Another option for determining the blackening achieved by the respective irradiation consists e.g. in observing the image plane B with a video camera 15' via a splitter mirror 16. Although both the pulse height sensor 15 and the video camera 15' are illustrated in the drawing, only one of the two apparatuses will usually be used to determine the blackening.

Instead of the illustrated arrangement of the video camera 15', it is also conceivable to arrange the latter in such a way that it is suitable for oblique observation of the image plane B, in other words that the optical axis OA_K of the video camera 15' does not coincide with the optical axis OA_L of the laser system 10. In the case of an oblique observation arrangement of this type, the splitter mirror 16 can then be omitted. However, in that case it is necessary to take account of distortion of the image plane that possibly occurs in the video image during the evaluation of the video signals.

Furthermore, it also appears to be possible to provide, instead of a video camera 15 with a two-dimensional photoreceiver arrangement, a linear photoreceiver arrangement, for example a photodiode linear array, or even just a single fast photoreceiver, it

then being necessary to use a corresponding one- or two-dimensional beam deflection device in order to be able to scan each dot $P_{k,l}$ of the image plane B.

In order to engrave an image, that is to say for example a portrait photograph of an identity card holder, a signature, further writing, graphical patterns or the like, into the radiation-sensitive layer that is suitable for laser engraving, the shutter device 11 is controlled in such a way that the radiation energy transmitted for each dot effects specific irradiation in the dot, and this results in the desired blackening. For this purpose, the pulse height of a transmitted laser pulse, that is to say the power thereof, is influenced with the aid of the shutter device 11 or with the controlled exit window of the laser system 10. If fluctuations occur in the radiation power or the beam intensity of the laser beam, then the consequence of this is that the irradiation generated at a dot $P_{k,l}$ does not effect the blackening sought.

In order to remedy this, according to a first refinement of the invention, after the irradiation of a dot $P_{k,l}$, the blackening actually obtained there is determined either directly or, preferably, from the measured beam power or pulse height and compared with the predetermined blackening for this dot $P_{k,l}$. If, by way of example, the intention is to obtain a blackening corresponding to a grey level 100 from 256 grey levels in a dot, then the shutter device 11 is driven accordingly. If, however, the blackening obtained corresponds only to the grey level 90 on account of statistical fluctuations in the beam intensity of the laser beam 13, in other words the blackening obtained is 10 grey levels short of the blackening sought, then this is taken into account during the subsequent irradiation of dots $P_{k,l}$.

In order to expediently utilize the information, determined during irradiation, about the blackening respectively achieved in the individual dots

$P_{k,1}$, it is possible, during a first irradiation pass, to reduce the blackening sought, in accordance with the statistical fluctuations in the output power of the laser system, relative to the predetermined total blackening for this dot $P_{k,1}$. If, by way of example, the fluctuation range of the laser system is 10%, then only 90% of the final blackening is sought in the first irradiation pass for each dot $P_{k,1}$ and the blackening obtained is detected. In that case, depending on the respective beam power or pulse height actually achieved, the blackening achieved in each dot lies between 81 and 99% of the blackening desired in the finished image. In a second irradiation pass, it is then possible to achieve the desired blackening for each dot with high accuracy, in that irradiation is effected in accordance with the additional blackening that is still required. Since the maximum deviation of the blackening obtained from the final blackening, given a statistical error of 10%, is approximately 20% in the case of the first irradiation pass, the total error in the finished image can thus be reduced to 2%.

According to another refinement of the invention, first of all an image to be engraved is produced dot by dot, in which case, however, only a fraction of the blackening intended for each dot is sought for this dot. If, therefore, a dot $P_{k,1}$ is intended to have a blackening corresponding to the grey level 100 in the finished image, for example, then the laser beam 13 is influenced by the shutter device 11 in such a way that it effects for example only 50%, 60%, or 70% of the blackening desired in the finished image. If it is now assumed that 60% of the total blackening is intended to be achieved in the first irradiation pass, then the grey level 60 is sought in the first irradiation pass for a grey level 100 sought in the final image. An additional blackening can then be sought in the second irradiation pass, which additional blackening, in turn, amounts to 60% of the difference between the present blackening and the blackening

sought in the finished image. In the numerical example represented, this corresponds to an additional blackening corresponding to grey level 24 and to a blackening of grey level 84 present in total after the second irradiation pass. In the third irradiation pass, an additional blackening in accordance with grey level 10 and a total blackening corresponding to grey level 94 are then sought. Only an additional blackening in accordance with grey level 6 need then be effected in the fourth and last irradiation pass.

If, after the first irradiation pass, it is ascertained that, instead of the blackening 60 sought, only the blackening 55 has been achieved in the dot $P_{k,1}$, then the grey level 84 can be sought in the second irradiation pass. On the other hand, it is also possible for an irradiation corresponding to 60% of the difference between the blackening achieved, that is to say grey level 55, and the blackening sought in the finished image, that is to say grey level 100, to be sought. This corresponds to an additional blackening corresponding to grey level 27 and a total blackening corresponding to grey level 82 present after the second irradiation pass.

This iterative irradiation method means that, by way of example, only 10% or less of the total blackening has to be achieved in the last irradiation pass. If the blackening can be obtained in each case with only a relative error of 10%, for example, and if the maximum error of 10% occurs during the last irradiation pass, then the relative blackening error referring to the total blackening is only 1%.

Consequently, the method according to the invention enables a laser system whose beam intensity is subjected to relatively large fluctuations to be used for the laser engraving of images, since the blackening values sought can be correspondingly corrected by virtue of the iterative irradiation of the radiation-sensitive layer in a plurality of irradiation passes and the determination of the respectively

obtained blackening in succeeding irradiation passes, as a result of which the relative blackening error referring to the total blackening can be drastically reduced.

Another option for obtaining the blackening in the image in a plurality of irradiation passes consists in that, by way of example, 60% of the total blackening in the finished image is sought in the first irradiation pass, while 90% of the total blackening has to be effected in the second irradiation pass and then only 10% of the total blackening has to be effected in the last irradiation pass.

In both procedures, however, it is particularly advantageous if the additional blackening sought in the last irradiation pass is so small that it already lies in the noise range.

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Patent Claims

1. Method for engraving images by means of radiation into a radiation-sensitive layer, in particular for laser engraving, in which the radiation-sensitive layer is irradiated in a point-by-point manner in such a way that the predetermined blackening for each dot ($P_{k,l}$) is obtained for the latter, **characterized in that**

- the blackening obtained in each dot ($P_{k,l}$) is determined, and
- during the subsequent irradiation of dots ($P_{k,l}$), the radiation energy is set as a function of sought and obtained blackening.

2. Method according to Claim 1, **characterized in that**

- in a first irradiation pass of each dot ($P_{k,l}$), irradiation is effected with a radiation energy that is reduced in a defined manner, with the result that the blackening sought in each dot ($P_{k,l}$) corresponds to a predeterminable fraction of the predetermined blackening for this dot,
- the blackening obtained in each dot ($P_{k,l}$) is determined, and
- in at least one further irradiation pass of each dot ($P_{k,l}$), irradiation is effected with a radiation energy which is set in accordance with the difference between the blackening already obtained and the blackening sought in this pass.

3. Method according to Claim 2, **characterized in that**

- in all of the irradiation passes except for the last, the radiation energy is set in such a way that the blackening additionally sought in the respective irradiation pass corresponds to the same fraction of the difference between the present blackening and the predetermined blackening for the respective dot ($P_{k,l}$), and

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- in the last irradiation pass, the radiation energy is set in such a way that the predetermined blackening for the respective dot ($P_{k,l}$) is sought.

4. Method according to Claim 2 or 3, **characterized in that**, in the last irradiation pass, the additional blackening sought corresponds to a luminosity difference below the perceptibility limit of the human eye.

5. Method according to one of the preceding claims, **characterized in that** in order to determine the blackening respectively obtained for each dot ($P_{k,l}$), the quantity of radiation that is radiated for the said dot is determined.

6. Method according to Claims 1 to 5, **characterized in that** laser radiation is used for the irradiation, and in that the blackening obtained in each dot ($P_{k,l}$) is determined from the respective radiation power.

7. Method according to Claim 6, **characterized in that** in order to generate the laser radiation, a laser system (10) operating in a pulsed mode is used and the blackening obtained in each dot ($P_{k,l}$) is determined from the pulse height of the laser pulse radiated for the respective dot ($P_{k,l}$).

8. Method according to one of Claims 1 to 4, **characterized in that**, during the laser engraving, the radiation-sensitive layer to be blackened is imaged onto a photoreceiver arrangement in order to determine the blackening obtained at the individual dots ($P_{k,l}$) from the luminosity values before and after an irradiation.

9. Method according to Claim 8, **characterized in that** a video camera (15) is used for determining the blackening, the video signals of which video camera are fed to an evaluation circuit in a control apparatus (14).

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