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(54) Title: A METHOD FOR PROVIDING AN OBJECT WITH A UNIQUE MARK

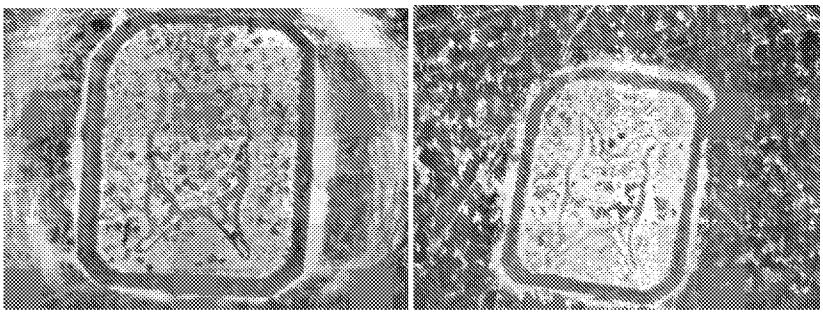

Figure 1

(57) Abstract: The present invention is enclosed in the area of unique marking of objects, for instance authenticity in assay or uniquely identifying and tracking an object. It is an object of the present invention a method for providing an object with a unique, comprising marking such object with a physical chaotic marking process on the surface of a portion of said object, such physical chaotic marking process consisting of i) random deposition of particles over the surface and further incrustation or ii) printing with a bondable fluid enriched with glitter particles, thereby providing a marking on such surface. The used processes, intrinsically chaotic, provide a unique character to the resulting object which is, thus, unique. An object obtained by such method and methods and devices for producing such object and reading it are also part of the present invention.

WO 2019/244081 A1

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DESCRIPTION

A METHOD FOR PROVIDING AN OBJECT WITH A UNIQUE MARK

FIELD OF THE INVENTION

The present invention is enclosed in the area of unique marking of objects, for instance authenticity in assay or uniquely identifying and tracking an object.

PRIOR ART

Prior art solutions exist where a marking is applied to an object.

In the area of assurance of authenticity, the object is typically a valuable object, the marking providing assurance of authenticity of the object by visual analysis, indicating, for example, that the object contains a certain degree of purity (in the case of gemstones and precious metals) or which has a certain provenance (in the case of food products, such as wine bottles). Examples of provenance or guarantee authenticity may consist of security documents (for identification, such as passports, national citizens' cards, driving licenses, visas, residence documents, etc.), certificates of authenticity (diplomas, certificates of formal qualifications, official stamps, etc.) and certificates of authenticity of products or trademarks (products of protected origin, trade marks, or others).

In the first case of gemstones stones and precious metals, the marking is applied by punching the object. In the case food products, a guarantee seal with certain visual characteristics is applied, typically further comprising a numbering.

In both cases, the marking that is intended to be unique is recognizable and the security against copy of the marking is dependent on access to the puncture and associated equipment or the equipment producing the said seals, or the ability to reproduce them.

On the other hand, and outside the area of guarantee of authenticity (although the solutions described below are equally applicable to this area), in order to validate, identify and trace a product, marking solutions are also known, such as codes with n-dimensions (bar codes, QR code, or others) or solutions with electronic components, such as RFID or other electronic-based solutions of greater constructive complexity.

The development of technology, in particular computing, makes these solutions less effective, since the ability of a machine to fully identify and hence reproduce/mimic such codes or devices is increasingly higher.

The present invention aims to address all of these problems by providing a solution that guarantees authenticity to an object and also allows validation, identification and tracking of the object, by introducing intrinsically unique techniques in the object marking process and consequently in the object itself.

SUMMARY OF THE INVENTION

It is an object of the present invention a method for providing an object with a unique marking, comprising marking such object with a physical chaotic marking process on the surface of a portion of said object, such physical chaotic marking process consisting of i) random deposition of particles over the surface and further incrustation or ii) printing with a bondable fluid enriched with glitter particles, thereby providing a marking on such surface. The used processes, intrinsically chaotic, provide a unique character to the resulting object which is, thus, unique. In the case of process i), the

incrustation of particles in an object provides the uniqueness of the marking, since the particles are randomly deposited over the surface and subsequently incrusted. The resulting marking is thus not reproducible, since a reproduction of the deposition and incrustation steps would render a different result. This is also true for the case of process ii), since glitter particles in a fluid are mobile, and thus provide a random organization, which is stabilized after printing. The printing of the surface with the bondable fluid enriched with such particles (i.e. a mixture of a bondable fluid with glitter particles) even promotes the random organization of particles within the fluid, therefore leading to a unique marking. Thus, and unlike prior art solutions, the present invention provides for truly unique marking of an object, while being constructively simple. The physical chaotic marking thus provides a random result.

In an advantageous configuration of the method of the present invention, the portion of the object consists of a incrustation portion made of a material with hardness and ductility which provide accommodation of incrusted particles, in particular the material consisting of a metal, a polymer or a resin, said physical chaotic marking process specifically consisting of i) incrustation of particles in the incrustation portion, such incrustation being performed by a) puncturing or b) application of a laser beam, on the surface of the incrustation portion, said particles being deposited on the surface prior to incrustation and therein incrusted after incrustation. Incrustation of particles may more efficiently be performed a) by puncturing (with a punch) of the particles into the object, which in the present case is a metal object, or b) by applying a laser beam on the surface of the incrustation portion, thereby fusing such area and providing incrustation of the particles into the surface. The incrustation portion material consists preferably of a metal, thus providing a metal portion. Where the incrustation portion material consists of a polymer, such polymer preferably consists of acrylic.

In another, alternative, advantageous mode of the method of the present invention, the physical chaotic marking process specifically consists of ii) printing with a bondable fluid enriched with glitter particles, where said printing being performed by

one of the following methods: serigraphy, flexography, rotogravure, carving, typography, offset, spray painting or direct printing with a brush embedded in said bondable fluid. Printing of a bondable fluid enriched with glitter particles may efficiently be performed on the surface of the portion of the object by one of the described methods.

It is also an object of the present invention an object which is obtained from the method of the present invention, in any of the described embodiments, such object comprising:

- a incrustation portion, the physical chaotic marking process being applied by i) incrustation of particles on the surface of such incrustation portion, or
- a portion, the physical chaotic marking process being applied by ii) printing with a bondable fluid enriched with glitter particles on the surface of such portion,

thereby providing a marking on the surface of the portion of the object. Such object is therefore uniquely marked, due to the chaotic/random properties of the methods used in its obtainment.

Furthermore, it is an object of the present invention the use of particles, in particular:

- diamond particles, preferably approximately spherical, or
- glitter particles, preferably of a mixture of a bondable fluid with such glitter particles, thereby providing a bondable fluid enriched with glitter particles,

for providing an unique mark. Such unique marking being provided in the object, which may consist of a stamp or the object to be marked itself.

It is yet an object of the present invention a machine for manufacturing an object with a unique marking, the machine being configured to implement the method of the present invention in any of the described embodiments comprising:

- i) means for random deposition of particles over a surface of an object and further incrustation of such particles in the surface or
- ii) means for printing a surface of an object with a bondable fluid enriched with glitter particles,

thereby providing a marking on such surface of the object. Such machine therefore uniquely marks objects, due to the chaotic/random properties of the means it comprises, therefore providing the advantages of the method of the present invention.

Furthermore, another object of the present invention is a method for capturing a marking, such marking being obtained by the method for providing a marking of the present invention in any of the described embodiments or being present in the object with a marking of the present invention, also in any of the described embodiments, the method for capturing the marking comprising the following steps:

- obtaining at least one digital image of the marking, preferably through a digital camera or microscope,
- segmenting particles on said digital image by means of image processing,
- determine a digital descriptor based on identified particles, the digital descriptor comprising information on visual, geometrical and/or morphological aspects of the particles in the marking, and
- compare such digital descriptor with a plurality of digital descriptors in a database, and thereby obtaining further information associated with a corresponding digital descriptor in the database.

Such method therefore provides an efficient way to capture and obtain relevant information from an object with a marking as obtained from the marking method of the present invention, or an object obtained from such marking method. A

computational apparatus comprising digital image acquiring means, preferably a digital camera or microscope, configured to implement the capturing method of the present invention in any of its embodiments, and a non-transitory storage media including program instructions executable to carry out the capturing method of the present invention in any of its embodiments are also objects of the present invention.

DESCRIPTION OF FIGURES

Figure 1 – images of a surface with a marking, in an object, obtained from the i) incrustation method of the present invention. Particles are visible. Such images consist of the digital images of the capturing method of the present invention. The incrustation portion is of gold (thus, a metal portion) in the image on the left and silver in the image on the right. The image was obtained with 200x zoom.

Figure 2 – image of a surface with a marking, in an object, obtained from the ii) printing method of the present invention. Particles are visible. Such images consist of the digital images of the capturing method of the present invention. Resolution is of 1080p and the bondable fluid is ink, in which glitter particles were mixed. Printing was performed through serigraphy.

Figure 3 – several digital images relevant for the capturing method of the present invention. Fig. 3 a) consists of a digital image of a marking obtained by incrustation. Fig. 3 b) consists of the same image, in which rectification was applied. Fig. 3 c) consists of the same as Fig. 3 b), after identification of particles. Fig. 3 d) consists of the same image as Fig. 3 c), in which geometrical properties (distances and angles between particles) were identified.

Figure 4 – several digital images relevant for the capturing method of the present invention. Fig. 4 a) consists of a digital image of a marking obtained by incrustation of diamond particles in the surface of a gold portion. Fig. 4 b) consists of the same image,

in which classification / mask produced by a convolutional neural network (CNN) was applied. Fig. 4 c) consists of the same image as Fig. 4 b), after selection of a region of interest with the mask, Fig. 4 d) consists of the same image as Fig. 4 c), after cut of the region of interest.

Figure 5 – several digital images relevant for the capturing method of the present invention. Fig. 5 a) consists of a digital image of a marking obtained by incrustation of diamond particles in the surface of a gold portion. Fig 5 b) consists of the same image, after manual identification of particles by a human operator, for training purposes, as described below. Fig 5 c) consists of the same image, after identification of particles by means of the capturing method of the present invention.

Figure 6 – example of an embodiment of the capturing method of the present invention, with registration steps.

Figure 7 – example of an embodiment of the capturing method of the present invention, with verification steps.

DETAILED DESCRIPTION

The more general and advantageous configurations of the present invention are described in the Summary of the invention. Such configurations are detailed below in accordance with other advantageous and/or preferred embodiments of implementation of the present invention.

Subsequently described advantageous embodiments of the method of the present invention are within the scope of physically marking by i) random deposition of particles over the surface and further incrustation.

In an advantageous configuration of the method of the present invention, incrustation of particles is specifically performed by a) puncturing on the surface of the incrustation portion by means of a metal punch over said pre-deposited particles on the surface.

In another advantageous of the method of the present invention, incrustation of particles is specifically performed by b) application of a laser beam on the surface of the incrustation portion and, prior to such incrustation, particles being pre-crimped on said surface. Therefore, a random organisation of particles is provided as in alternative process a), of puncturing, although particles are not truly incrusted but only partially fixed to the surface. It is the application of a laser beam that incrusts the particles, already randomly organised by the pre-crimping.

In another inventive aspect, the particles consist of diamond particles, preferably approximately spherical, therefore providing resistance to the impact of puncturing or the effect of laser, and also providing evenness of particles, with a generally spherical form.

In another preferred embodiment, said particles of have an average area of 0.7-3.2 % of the area of the incrustation portion, preferably the particles having a diameter between 50-100 μm and the surface of the incrustation portion having an area of 1-4 mm2, optionally such surface of the incrustation portion consisting of a square with 1-2 mm sides. Such relation between areas provides for a good visual organization of particles in the metal, thereby enhancing optical or visual reading methods.

Preferably, the particles have a high contrast with the incrustation portion, preferably having a colour which provides high contrast with such incrustation portion.

Preferably, the incrustation portion comprises or consists of a precious metal, preferably one or more of the following: gold, silver, platinum or palladium. It may be – although in no way necessary – that the whole object is made of the same material or materials as the incrustation portion.

As an example, we can define the incrustation of diamond particles in metal artefacts, usually precious metals (gold, silver, platinum and palladium). The application process can be performed by punching or through a laser beam. The size of the particles varies depending on the intended applications but, as an example, they may be particles of 50 to 100 µm in 1mm side markings.

Variables consist of:

- Particle Material, preferably diamond
- Particle size, preferably 50 to 100 micrometers
- Particle Format, preferably roughly spherical
- Dimension of the mark, surface of the portion, preferably approximately quadrangular with 1mm of side

the objective being to provide an unique assay marking on precious metals.

Process described as a) comprises placement of the particles, preferably deposition on the metal surface, and crimping the particles by puncturing using a metal punch, over the pre-deposition of particles.

Process described as b) comprises placement of the particles, preferably by deposition on the metal surface, and particle crimping by incidence of a laser beam, with or without pre-crimping of the particles for initial fixation.

Subsequently described advantageous embodiments of the method of the present invention are within the scope of physically marking by ii) printing with a bondable fluid enriched with glitter particles.

In an inventive aspect of the method of the present invention, the bondable fluid enriched with glitter particles is obtained by mixing glitter particles into a bondable fluid, prior to printing. Such mixing enhances the random organisation of glitter particles within the bondable fluid.

Preferably, printing is specifically performed by serigraphy with a net, the net being such it provides passing of the glitter particles through it.

Preferably, and for evenness, the glitter particles have a diameter between 50-100 μm.

Preferably, the glitter particles consist of metal particles non solvent in the bondable fluid, such particles preferably being spherical or discoidal.

Preferably, said bondable fluid consists of ink, glue, a resin or varnish.

In another inventive aspect, said glitter particles are such that have high contrast with said bondable fluid, the bondable fluid said bondable fluid preferably having transparency. More preferably, the fluid is transparent. Thus, the glitter particles will be even more visible, in their contrast with the bondable fluid.

Variables consist of:

- Particle Material, preferably metal glitter particles
- Particle size, preferably 50 to 100 micrometers
- Particle Format, preferably roughly spherical or discoidal
- Density of the material, as desired

– Dimension of the mark, on the surface of the portion, as desired

the objective being to provide an unique printed marking with the desired dimension and format.

The process comprises placement of the particles, by mixing the powder particles with the bondable glue, preferably ink, to be applied, and printing using screen print technique with a net wide enough to allow the passage of glitter particles, other printing processes also being suitable.

The printing of glitter-mixed inks can be applied to almost all printing processes, which means they can generate unique images by instantiation. Each of these processes can be fine-tuned by defining the variables mentioned above. Some of the processes that can be applied are:

- Flexography
- Rotogravure
- Carving
- Typography
- Offset
- free manual painting with the use of a conventional brush.

With regard to both methods, certain options may provide enhanced results, as above described.

Contrast: existence of high visual contrast between the particles and the carrier material where the marking is created. In the examples used, it is desirable that the colour of the glitter particles be differentiated from the colour of the paint and / or colour of the carrier material (paper, polymer, PVC, polycarbonate, wood, among other carrier materials) when applied with inks or transparent glues or with a high transparency index. On the other hand, in the case of precious metal marks, given the hardness of the carrier, it is desirable that the colour of the particles be differentiated from the colour of the metal.

Particle resistance: high particle resistance in terms of physical and chemical integrity to the process of marking creation. Depending on the marking process, the particles may suffer a physical shock that fractures or destroys them partially or completely. For this reason, it is desirable that the particle be of a material resistant to the physical process. In the case of marking in metals, one of the most suitable materials for the marking process is the diamond (carbon element), given its high physical strength. From the chemical point of view, it is also desirable that the particles maintain their physical integrity and chemical composition, and be stable throughout the life cycle of the marking. In the case of glitter-enriched inks, one of the suitable materials is non-soluble metal particles in the solvents, glues, resins and paints where they will be mixed.

Density: existence of low density and non-high amount of particles along the marking. The amount of particles may range from 10 to 1000 for a common label, although it is desirable that the number of particles be between 30 and 200. A higher or lower particle value does not compromise the marking, but may reduce the ability of a system to identify it. As to density, it is desirable that there be no particle agglomeration, for this purpose the use of a low density dispersion is desirable.

With regard to the object obtained by the method of the present invention, it may consist of:

- a metal piece, preferably of a precious metal such as gold, silver, platinum or palladium, thereby consisting of a precious piece, such as a jewellery piece, a precious metal piece, an ingot, a precious piece which is used in the mechanism of machinery or a piece of art, among other possible examples, and the unique marking consisting of a mint mark, the incrustation portion consisting of a portion of such metal piece, and the physical chaotic marking process being applied by i) incrustation of particles, or

- a cellulose or polymer based piece, preferably polycarbonate (PC), polyvinyl chloride (PVC), wood or paper, the portion consisting of a portion of the surface of such piece, and the physical chaotic marking process being applied by ii) printing the surface with a bondable fluid enriched with glitter particles.

With regard to the capturing method of the present invention, also advantageous aspects exist, as subsequently described. The capturing method may further comprise rectifying the digital image, prior to particle segmentation, such rectifying comprising:

- detecting a region containing a marking in the image, through feature search and identification, detection of such region preferably comprising:
  - implementation of a convolutional neural network on the region of the image, such network having been trained over pre-acquired data relating to other markings,
- applying a transformation in such region, such transformation comprising removing perspective effects and/or a desired orientation.

Such rectification provides a more suitable image to analyse, i.e., to in which particles and further details are detected.

The particle segmentation of the capturing method may also further comprise implementing a convolutional neuronal network on the image, preferably on said region of the image, such network having been trained over the image and a mask containing already identified particles.

The capturing method may also further comprise associating a digital descriptor with additional information and storing both the digital descriptor and additional information in a relational database, thereby registering such digital

descriptor, preferably where no corresponding digital descriptor from the plurality of digital descriptors in a database was identified, preferably the additional information comprising one or more of the following: date, time, localisation, owner reference, manufacturer reference, information on each sale / transition of ownership of the piece, information on remodelling or any procedure implemented on the piece.

EMBODIMENTS

Specific embodiment details relative to both capturing and analysing digital images according to the capturing method of the present invention, as well as the apparatus that implements such method, are subsequently described.

For objects with incrustation marking, given the reduced size of the marking, the most suitable reading system would most suitably have a magnification capability for the particles to be individually detected. This system could be a microscope (with enlargements of 100x, 200x or higher) or a conventional chamber of great magnification. Another suitable reading system is the camera of a smartphone or tablet with a lens attached.

The image acquisition process should be optimized to collect one or more images under predefined lighting, positioning and magnification conditions. Ideally the equipment should be capable of capturing 5 megapixel images in the case of magnifications greater than 200x and 12 megapixels in case the equipment is a smartphone or tablet, with or without magnifying accessory lenses, and the marking must be completely visible, without occlusions or cuts. Figure 1 illustrates two examples of markings captured with a microscope. These resolution values are indicative of solutions with high robustness, however, the reading system may have a lower resolution, which does not compromise the robustness of the solution in most cases.

For objects with printing marking, depending on the size of the glitter particles and the area of the mark, the reading system could be a conventional camera or the camera of a mobile device, or even a microscope, but it is not usually necessary to use the latter.

The image acquisition process must be able to capture all the particles of a marking. The acquisition equipment may be a mobile phone with a common camera attached. The capture can be done preferably, but not exclusively, with resolution equal to or greater than 1080p. Since the interaction of the particles with light differs according to the direction of incidence of the latter and from the point of view of the acquisition, it is preferable to capture more than one image and to identify the particles in all of them and subsequently to compose the description of the marking (as described in Section 3: Image Descriptor). Figure 2 shows a glitter marking captured with the camera of a mobile phone.

As above described, a digital descriptor that combines visual aspects, geometric characteristics and/or morphological characteristics is used. The function of a digital descriptor is to enable the marking validation operation, without recourse to the original image, that may be available or not at the time of validation and, consequently, to improve the speed of obtaining a validation result.

The visual aspects of a marking are described through image characterization methods, such as: descriptors of local characteristics, textures, hue, minutiae, among others. Two images of the same marking are compared through local (pixel-by-pixel) or global (general structure from image) relationships. In order to better perform a local comparison it is necessary to perform a correct alignment between two images captured from the same mark, through rectification.

The computation of local characteristics may be carried out by the implementation of corner and edge detection algorithms such as ORB [Oriented

Features from Accelerated Segment Test (FAST) and Rooted BRIEF (Binary Robust Independent Elementary Features)], among other possible methods. These methods allow to detect and compare small sections (typically 5x5 pixels) in order to find matches.

The detection and characterization of the surfaces of the marking and of the pieces comprising it may be supported by extraction of data through the filtering of the images with filters of Local Binary Markings (LBP), allowing to distinguish surfaces with different attributes.

The gathering of information of hue is relevant, since it allows to identify the type of material on which the marking is applied. By analysing the RGB channels of the image it is possible to identify, for example, the type of metal being analysed, or the type of pigment in which the glitter is immersed.

Minutiae detection refers to implemented mechanisms capable of identifying and characterizing imperfections or indentations created by the marking on the surface on which the marking was applied or created by the particles themselves that make up the marking.

Since the elements in the marking consist of particles that are detected, their relative and absolute positions in the marking and their shape being known, it is possible to characterize the marking also on the basis of this information. From the mask identifying the particles (Fig. 3c)), characteristics describing their morphology are calculated, for example, size, circularity, aspect ratio, particle density, distance to the centre of the marking, between others. Once these characteristics are calculated, their distribution in a histogram is studied and values are collected at specific frequencies of the histogram which then constitute the morphological aspects of the marking in question.

The geometric aspects of a marking are described by histograms of characteristics associated with the sequence or sets of particles (a marking is composed of several particles). Among these aspects, we firstly use the distance between sets (the order of points does not matter) of two particles and the angle formed by the sequence (points chosen in a specific order) of three particles (Fig. 3d)).

Such a histogram consists of a vector of integers that account for the occurrence of value ranges of a given characteristic among all sets / sequences of points associated with the particles. Figure 3d illustrates the calculation of the distance between two pairs of points, as well as the angle formed by a sequence of three other points.

Assuming that the image is properly rectified (as explained in Section 4.1), and the particles have been properly identified (as explained in Section 4.2), the calculation of the histogram consists of the following steps:

- For each region associated with a particle identify a representative point (this point is the centre of this region)
- Normalize (according to the marking region) the coordinates of the representative points of the particles between two values, for example 0 and 100
- Initialize the histogram (for example, with 141 elements in the case of distance, and 181 elements in case of angles)
- For each sequence of points (a pair in the case of distance, and a trio in the case of angles) calculate the geometric characteristic of the points (angle or distance)
- Calculate the histogram index relative to such characteristic (integer value approximation of the characteristic)
- Increment a unit on the histogram element for such calculated index.

With regard to rectification, a marking can be photographed at different distances and from different points of view. Thus, in order to calculate the descriptors of a marking (visual, morphological and geometric) it is necessary to initially transform

the image so that the marking appears integrally, without perspective, and with the same orientation in all the images. This phase is called rectification. To do this, it is necessary to (i) detect the marking through a characteristic identification that allows it to be recognized in the image, (ii) apply a transformation in the marking region to leave such a region without the initially mentioned deformations.

Marking image detection aims at extracting the region of interest for further processing. The extraction of the zone of interest allows the system to operate only on a part of the image, reducing the computational effort required, as well as increase the chances of success with particle detection and segmentation. In addition, it also allows a more efficient management of the information that is stored in the database, due to the smaller size of the image that needs to be retained.

The process of marking detection is achieved at the expense of, for example, the implementation of a convolutional neural network (CNN), called U-Net. This neural network is an algorithm capable of recognizing which zones of the image that contain the marking that is the zone of interest. This network is trained on a set of data acquired during the system building process and can be updated and re-trained as the amount of information available in the database increases.

With regard to particle identification, a possible algorithm is based on the use of a U-Net convolutional neural network (CNN), trained directly on the image and its mask with the identified particles. For each marking used in the training of this network, the image of the marking is presented, the true segmentation of the particles (carried out manually).

With regard to registration of a marking, its respective digital descriptor is created and added to a database. The database record may contain, in addition to the original captured image, its geometric and visual descriptors as well as other additional information (examples: date, time, location, observations, owner, manufacturer). The

set of stored information will later be used by the system to confirm the authenticity of the marking.

With regard to validation of a marking, it can be performed by two different operations, with different objectives and purposes: verification and identification. On the one hand, given an image of a marking, a set of characteristics of this marking are determined (targeting masks, particle position, random marking descriptors, etc.), which are evaluated by the model in the sense of identifying which marking which is sufficiently similar to the standard presented, in the case of identification. This validation process, called identification, is a 1-to-many search. On the other hand, the validation process can be performed as a verification process. In the case of verification, this set of characteristics is compared only with the characteristics of the marking whose identity is known or suggested, becoming, therefore, a 1-to-1 search.

Fig. 6 shows an example of the complete registration process in a database of a diamond-on-metal particle dispersion marking.

With regard to verification – when verifying the authenticity of a marking – its image must be captured by any reading system, preferably similar to the system used for marking registration. Once the image is acquired, it will be processed. The processing (Fig. 7 (a) to (d)) generally includes the following operations: marking detection, identification of the carrier material, identification of the standard material, rectification and standardization of the marking for standard scale and orientation, detection of the particles forming the randomness and the calculation of the digital descriptors that characterize it, as above described.

Next, the descriptor of the marking to be checked will be purchased with the descriptor of the marking with which the comparison is intended, stored in database. In order for the descriptors of a given marking to correspond, even when the

reading processes are performed at different times and by similar but different acquisition systems, the two marks are subjected to the same standardization operations described above (Fig. 7 e)). If this comparison, measured by a sufficiently effective likelihood measurement model, returning a sufficiently high score, then the marking is validated as being the same marking stored.

With regard to identification of the authenticity of a marking, its image must be captured by any reading system, preferably similar to the system used for marking registration. Once the image is acquired, it will be processed. The processing (Fig. 8 (a) to (d)) generally includes the following operations: marking detection, identification of the carrier material, identification of the material constituting the standard, rectification and standardization of the marking for standard scale and orientation, detection of the particles forming the random marking and calculation of the descriptors that characterize it, as described above (Fig. 8 a) to d)).

After the descriptor of the marking to be identified has been calculated, it will be compared to the descriptors stored in the database, which contains all the marking to be searched. The research process is not simple and its complexity depends on the size of the database, among other factors. The comparison can be made using a cost metric between descriptors, producing a comparison value. In addition, the process can be accelerated through an indexed search and hypothesis elimination system (Fig. 8 e). From this comparison will appear a list of the candidate markings, that is, those whose descriptors are more similar to the marking under verification.

The identification process may include several passages through this process of successively reducing the number of candidate markings until a comparison with a degree of confidence sufficient to generate a final response appears.

The identification process can be structured at several levels, so that when one level generates more than one candidate marking, then the next level will

initiate a new identification process with this list of candidate markings. New descriptors relating to this level should be calculated from this list.

Some of the operations that can be used for the second level of research include processes of image alignment by homography techniques, comparison of marking geometry, and measurement of similarity of descriptors. If one of these comparisons returns a sufficiently high score, the marking identity is confirmed.

As will be clear to one skilled in the art, the present invention should not be limited to the embodiments described herein, and a number of changes are possible which remain within the scope of the present invention.

Of course, the preferred embodiments shown above are combinable, in the different possible forms, being herein avoided the repetition all such combinations.

CLAIMS

1. A method for providing an object with a unique marking **characterised in that** it comprises marking such object with a physical chaotic marking process on the surface of a portion of said object, such physical chaotic marking process consisting of i) random deposition of particles over the surface and further incrustation or ii) printing with a bondable fluid enriched with glitter particles, thereby providing a marking on such surface.

2. A method according to claim 1 wherein said portion of the object consists of a incrustation portion made of a material with hardness and ductility which provide accommodation of incrusted particles, in particular the material consisting of a metal, a polymer or a resin, said physical chaotic marking process specifically consisting of i) incrustation of particles in the incrustation portion, such incrustation being performed by a) puncturing or b) application of a laser beam, on the surface of the incrustation portion, said particles being deposited on the surface prior to incrustation and therein incrusted after incrustation.

3. A method according to the previous claim wherein incrustation of particles is specifically performed by a) puncturing on the surface of the incrustation portion by means of a metal punch over said pre-deposited particles on the surface.

4. A method according to claim 2 wherein incrustation of particles is specifically performed by b) application of a laser beam on the surface of the incrustation portion and, prior to such incrustation, particles being pre-crimped on said surface.

5. A method according to any of the claims 1-4 wherein such particles consist of diamond particles, preferably approximately spherical.

6. A method according to any of the claims 1-5 wherein said particles of have an average area of 0.7-3.2 % of the area of the incrustation portion, preferably the particles having a diameter between 50-100 μm and the surface of the incrustation portion having an area of 1 mm^2, optionally such surface of the incrustation portion consisting of a square with 1 mm sides.

7. A method according to any of the preceding claims wherein said particles have a high contrast with the incrustation portion, preferably having a colour which provides high contrast with such incrustation portion.

8. A method according to any of the claims 2-6 wherein said incrustation portion comprises or consists of a precious metal, preferably one or more of the following: gold, silver, platinum or palladium.

9. A method according to claim 1 wherein said physical chaotic marking process specifically consists of ii) printing with a bondable fluid enriched with glitter particles, said printing being performed by one of the following methods: serigraphy, flexography, rotogravure, carving, typography, offset or direct printing with a brush embedded in said bondable fluid.

10. A method according to any of the claims 1 or 9 wherein bondable fluid enriched with glitter particles is obtained by mixing glitter particles into a bondable fluid, prior to printing.

11. A method according to any of the claims 9-10 wherein said printing is specifically performed by serigraphy with a net, the net being such it provides passing of the glitter particles through it.

12. A method according to any of the claims 1 or 9-11 wherein the glitter particles have a diameter between 50-100 μm.

13. A method according to any of the claims 1 or 9-12 wherein the glitter particles consist of metal particles non solvent in the bondable fluid, such particles preferably being spherical or discoidal.

14. A method according to any of the claims 1 or 9-13 wherein said bondable fluid consists of ink, glue, a resin or varnish.

15. A method according to any of the claims 1 or 9-14 wherein said glitter particles are such that have high contrast with said bondable fluid, the bondable fluid said bondable fluid preferably having transparency.

16. An object **characterised in that** it is obtained from the method of any of the preceding claims, such object comprising:

– a incrustation portion, the physical chaotic marking process being applied by i) incrustation of particles on the surface of such incrustation portion, according to any of the claims 1-8 or

– a portion, the physical chaotic marking process being applied by ii) printing with a bondable fluid enriched with glitter particles on the surface of such portion, according to any of the claims 1 or 9-15, and

thereby providing a marking on the surface of the portion of the object.

17. An object according to the previous claim wherein it consists of:

– a metal piece, preferably of a precious metal such as gold, silver, platinum or palladium, thereby consisting of a precious piece, and the unique marking consisting of a mint mark, the incrustation portion consisting of a portion of such metal piece, and the physical chaotic marking process being applied by i) incrustation of particles, or

– a cellulose or polymer based piece, preferably polycarbonate (PC), polyvinyl chloride (PVC), wood or paper, the portion consisting of a

portion of the surface of such piece, and the physical chaotic marking process being applied by ii) printing the surface with a bondable fluid enriched with glitter particles.

18. Use of particles, in particular:

– diamond particles, preferably approximately spherical, or

– glitter particles, preferably of a mixture of a bondable fluid with such glitter particles, thereby providing a bondable fluid enriched with glitter particles,

for providing an unique mark by random deposition of such particles.

19. A machine for manufacturing an object with a unique marking, configured to implement the method of any of the claims 1-15 and comprising:

– i) means for random deposition of particles over a surface of an object and further incrustation of such particles in the surface or

– ii) means for printing a surface of an object with a bondable fluid enriched with glitter particles,

thereby providing a marking on such surface of the object.

20. A method for capturing a marking, such marking being obtained by the method of any of the claims 1-15 or being present in the object of any of the claims 16-17, **characterised in that** it comprises the following steps:

– obtaining at least one digital image of the marking, preferably through a digital camera or microscope,

– segmenting particles on said digital image by means of image processing,

– determine a digital descriptor based on identified particles, the digital descriptor comprising information on visual, geometrical and/or morphological aspects of the particles in the marking, and

– compare such digital descriptor with a plurality of digital descriptors in a database, and thereby obtaining further information associated with a corresponding digital descriptor in the database.

21. A method according to the previous claim wherein it further comprises rectifying the digital image, prior to particle segmentation, such rectifying comprising:

– detecting a region containing a marking in the image, through feature search and identification, detection of such region preferably comprising:

o implementation of a convolutional neuronal network on the region of the image, such network having been trained over pre-acquired data relating to other markings,

– applying a transformation in such region, such transformation comprising removing perspective effects and/or a desired orientation.

22. A method according to any of the claims 20-21 wherein particle segmentation comprises implementing a convolutional neuronal network on the image, preferably on said region of the image, such network having been trained over the image and a mask containing already identified particles.

23. A method according to any of the claims 20-22 wherein it further comprises associating a digital descriptor with additional information and storing both the digital descriptor and additional information in a relational database, thereby registering such digital descriptor, preferably where no corresponding digital descriptor from the plurality of digital descriptors in a database was identified, preferably the additional information comprising one or more of the following: date, time, localisation, owner reference, manufacturer reference.

24. A computational apparatus comprising digital image acquiring means, preferably a digital camera or microscope, configured to implement the method of any of the claims 20-23.

25. Non-transitory storage media including program instructions executable to carry out the method of any of the claims 20-23.

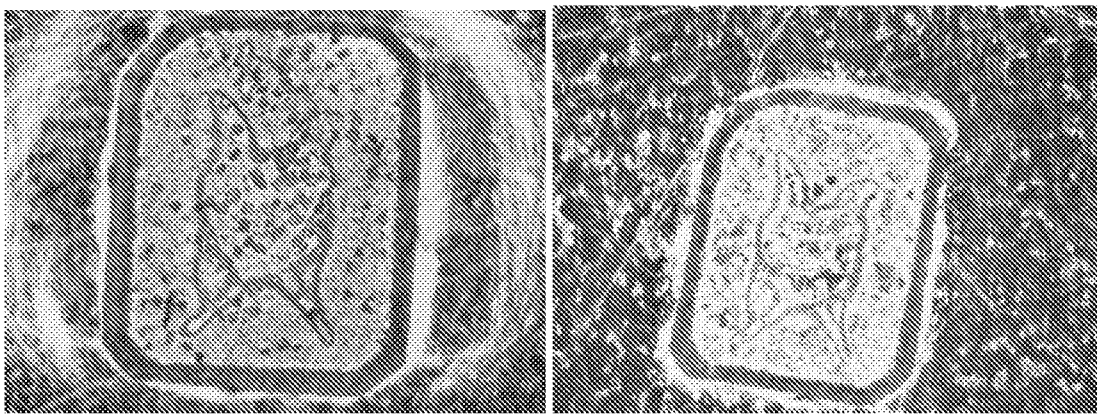

Figure 1

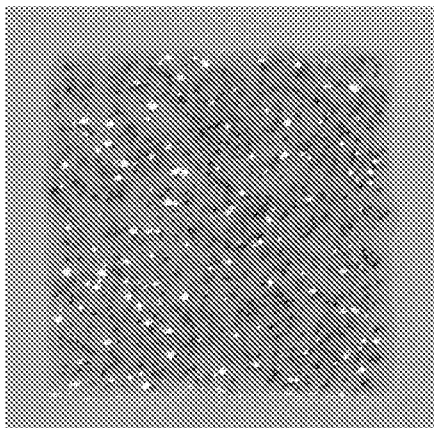

Figure 2

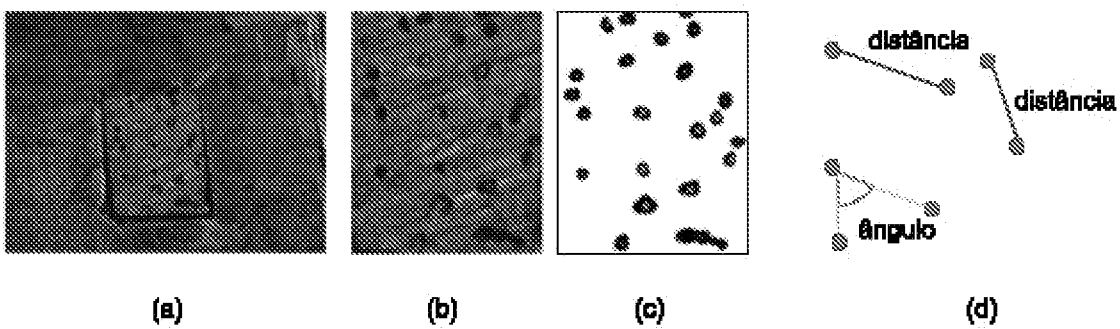

Figure 3

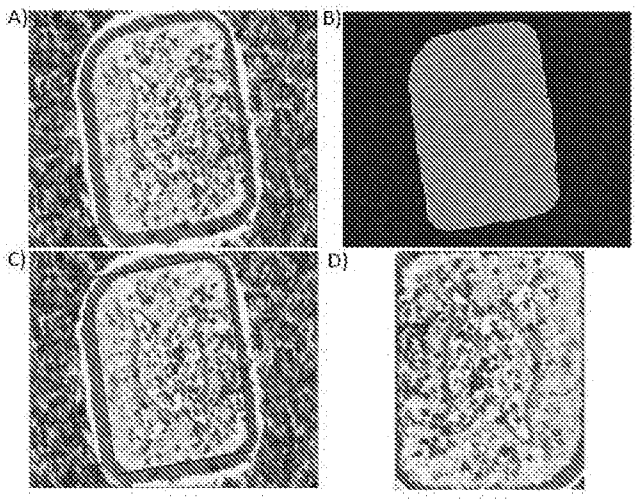

Figure 4

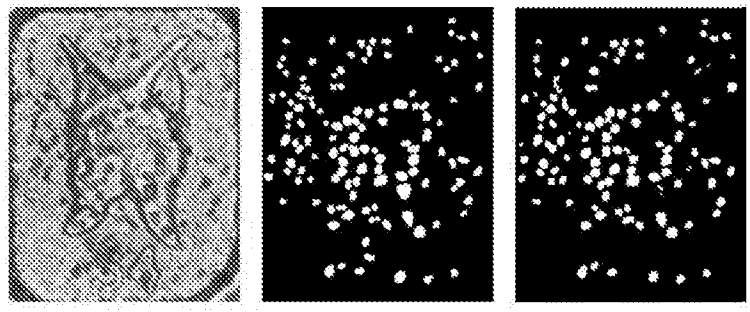

Figure 5

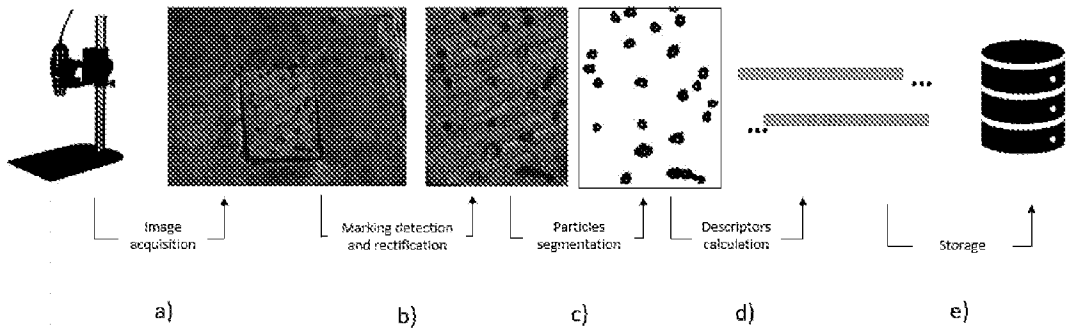

Figure 6

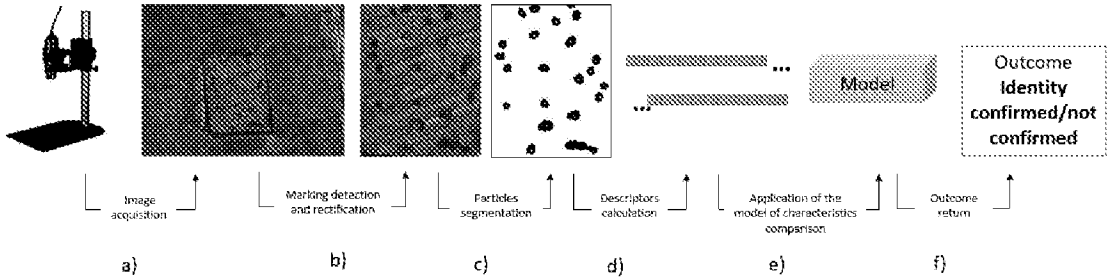
Model
Outcome
identity
confirmed/not
confirmed
Image acquisition
Marking detection and rectification
Particles segmentation
Descriptors calculation
Application of the model of characteristics comparison
Outcome return
a)
b)
c)
d)
e)
f)

Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2019/055177

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41M3/00 B41M3/14 B41M7/00 B44F1/02 B44F5/00
B41M5/26
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41M B44F B44C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2008 015466 A1 (INFORMIUM AG [DE]) 24 September 2009 (2009-09-24) paragraphs [0001], [0011], [0013], [0019], [0020], [0022] - [0024], [0029] - [0034] claims 1,7-10	1,9-25
X	US 2016/376674 A1 (SOLOWAY DANIEL DAVID [US]) 29 December 2016 (2016-12-29) paragraphs [0022], [0023], [0024], [0030]	1,2,4, 6-8, 16-19
X	US 2018/029304 A1 (PAULI UWE [CH] ET AL) 1 February 2018 (2018-02-01) paragraphs [0068], [0070] claims 1,18	1-3,5-8, 16,18,19

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 October 2019	25/10/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Pulver, Michael

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/IB2019/055177

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		WO 2016131525 A1	25-08-2016