

Field of Invention

The present invention relates to particulate based compositions for deposition on substrates, a system and method for the deposition of the said compositions for preparation of a clone-proof monetary and/ or security documents. The invention further relates to a system for application of the said composition as an identifier at predetermined location on the substrate, capturing magnetic / magneto-optical signal from the said applied composition on the said substrate, digitizing, storing, embedding and encrypting the same as an invisible or visible two dimensional (2D) barcode on the substrate as an associated identifier so as to create a dedicated, non repeatable and unique functional digitised relation between two said identifiers and/or any other identifier(s) linked to a specific object.

Background of the Invention

A process of identification and authentication of an object is necessarily based on dedicated identifier information or set of identifiers associated with the said object. The process of authentication generally involves the capturing of identifier information and validating it with a database of stored identifier information corresponding to the said object. The identifiers are either introduced in the substrate during the manufacture of the substrate or may be introduced onto the substrate (e.g. Paper, woven paper, woven cloth, plastic films, cotton pulp based substrates etc.) after the manufacture of the substrate which is predominantly the case in the case of financial documents, currency, mark lists, certificates etc.

The challenge lies in providing a system for applying the identifier on predetermined locations of the preformed substrate on an industrial scale simultaneously ensuring the precision with which that identifier is applied on the predetermined location of said substrate. Further the challenge lies in robustly applying the identifier on the said substrate such that it survives the onslaughts of long term repeated handling of the substrate and exposure to repeated adverse factors like crumpling, rubbing, wetting etc. Further the challenge lies in effectively digitally capturing the identifier representation, creating databases and effectively utilising them for the identification and authentication of an object comprising of the said substrate.

Summary of the Invention

The main object of the invention is to provide particulate based compositions for deposition on preformed substrates, a system and method for the deposition of the said compositions on the said substrates.

Another object of the invention is to provide method of preparation of the said particulate based composition.

Another object of the invention is to provide a system for deposition of the said compositions as an identifier at a predetermined location(s) on a substrate, digitally capturing the representation of the composition as deposited on the said substrate and storing the same in an encrypted format.

Another object of the invention is to provide a system for depositing the said composition an identifier at predetermined location on the substrate, capturing magnetic / magneto-optical signal from the said applied composition on the said substrate, digitizing, storing, embedding and encrypting the same as an invisible or visible 2d barcode on the substrate as an associated identifier so as to create a dedicated, non repeatable and unique functional digitised relation between two said identifiers and any other identifier(s) linked to a specific object.

Another object of the invention is to provide compositions comprising particles of at least one metal and /or metal oxides of particle sizes ranging from 100 nm to 100 microns.

Another object of the invention is to provide a system for the application of the said compositions at predetermined locations on preformed substrates in roll and / or sheet form moving at substantial speed.

Yet another object of the invention is to deposit the compositions on a substrate selected from plastic, paper, woven fibre, non-woven fibre structure.

Yet another object of the invention is to provide a system to deposit the compositions on a substrate that is in motion at a speed ranging from 0.6 meter / sec to 5 meters / sec.

Yet another object of the invention is deposit the said compositions on a substrate so
5 that it is robustly adheres to the substrate in a manner to survive long term handling of the object comprising of the said substrate containing the applied composition.

Yet another object of the invention is to create an identifier on the substrate for precise location and detection of the composition deposited on the substrate. The creation of
10 this identifier is accomplished either before or after deposition of the composition on the substrate.

Yet another object of the invention is to ensure formation of protective layer over the deposit of the applied composition.

15 Yet another object of the invention is to deposit the said compositions on the substrate so as to avoid undesirable localized agglomeration / aggregate formation. .

Yet another object of the invention is to provide a ductile composite on the substrate to
20 impart crumpling resistance.

Yet another object of the invention is to provide scuff and wash resistant compositions for application on the said preformed substrates.

25 Another object of the invention is to provide a system and method to create protective overlay on the identifier to prevent it from any damage due to abrasion mechanical working, etc during long term usage.

Yet another object of the invention is to magnetize the deposited particles after applying
30 the same vide the said compositions on the said substrate.

It is yet another object of the invention to provide an overlay that functions as a self marking for a reading device reader to locate the region on the substrate where the magnetized particles are located.

Another object of the invention is to provide a system to create digital representation having 3D signal structures (fingerprint) using the signal captured from the magnetized particles deposited on the preformed substrate that acts as a first identifier. Further
5 object of the invention is to embed the said 3 D signal structure in an encrypted format into a 2 D barcode / image which then can be printed onto substrate as a second identifier for irrefutably linking the first identifier and second identifier.

Another object of the invention is to provide a system to capture digital representation at
10 substantially high speeds of the order of 100-300 milliseconds per deposition.

Yet another object of the invention is to provide a system for conversion of the digital representation into an encrypted barcode ready for print in time intervals of the order of 100-300 milliseconds per digital representation. Further object of the invention is to
15 print the encrypted barcode / image at time interval of less than 300 milliseconds per barcode / image.

Another object of the invention is to provide the said identifiers on currency notes, financial documents, mark lists, transcripts etc.

20 Thus in accordance with the invention a lone proof document comprising a substrate provided with a particulate composition as an identifier at a predetermined location, barcode and/or image as an associated identifier
25 wherein there is a unique functional relation between two said identifiers of the substrate wherein

the system for preparation and functionalization of the said substrate comprises of
30 an applicator means (1) and a data capture system (2)
wherein the applicator system
a drying station (11),
a device to magnetize the composition on the substrate,

the data capture system (2) comprising a data capture centre (21) comprising first magneto-optic reading system, data-matrix printing station (22) and print verification station (23), a second reading device that is deployed in the field for end-user

wherein

5 the said magneto-optic reading system captures the signal from the said particulate composition identifier of the said substrate and transforms it into a magneto-optical image to assign a signature to the said particulate based composition of the substrate,

10 the said signature is then embedded in an encrypted into a barcode / image as an associated identifier that is printed onto the substrate for irrefutably linking the said signature of the particulate deposit identifier with the associated identifier to create a unique functional relation between the said two identifiers.

DETAILED DESCRIPTION OF THE INVENTION

15 Features and advantages of this invention will become apparent in the following detailed description and the preferred embodiments with reference to the accompanying drawings.

20 The system of the present invention as illustrated in Figure 1 comprises of deposit applicator means 1 and a data capture system 2. The applicator system comprises either of the means such as spot dispensing, flat bed screen printing (screen fixed and squeegee moves), flat bed screen printing (screen moves and squeegee fixed), rotary screen printing for application / deposition of the composition on the substrate. The drying station 11 comprises a means for curing of the deposited paste either by heat curing or by UV curing depending on the constituents of the medium of the particulate composition. Further there is a means (not shown) in the system 1 to magnetize the applied / deposited composition on the substrate. A signature is associated to particulate based compositions applied on a substrate by capturing magnetic field
30 strength signals from the said substrate and transforming it into a magneto-optical image. The data capture system 2 comprises of data capture centre 21 comprising first magneto-optic reading system, data-matrix printing station 22 and print verification station 23. The second magneto-optic system (not shown) is deployed in the field for the user.

The said process of assigning signature to the particulate based composition is carried out during printing process. Figure 4 and Figure 5 depict details. It comprises steps of:

- ✓ creating reference coordinate system during printing process of substrate 415 (Figure 4) (such as currency) by printing fiducial marks on top of the applied particulate based composition identifier 400 so that an origin and orientation can be determined from the fiducial marks;
 - ✓ Fiducial marks include but are not limited to: a cross-hair, square, rectangular, circular or linear marks, or any combination of the above;
 - ✓ Capturing magneto-optical image from the particulate based composition 400 with the aid of the sensing means 410 the said data capture system 2;
 - ✓ Dividing the said image into multiple regions using the fiducial marks as a coordinate system;
 - ✓ Checking the said regions for magnetic field strength variation for explicit signature creation;
 - ✓ Storing magneto-optical image in the said data capture system 2 database as its full reference signature for particular substrate such as currency;
 - ✓ Creating a partial magneto-optical reference signature;
 - ✓ Encryption of the said partial reference signature using AES 128 for symmetric key encryption, or by using a public/private key pair if asymmetric encryption is preferable;
 - ✓ Compressing and encoding the said partial reference signature into a barcode 500 (Figure 5) that is printed on the substrate 415
- By reconstructing the partial reference signature from the barcode 500 printed on the substrate 415 and matching against a newly acquired magneto-optical signature, a reading system associated with the present invention can determine whether the two match or correlate without using the full reference signature stored in the system database;
- ✓ Reading the particulate based composition using the said first magneto optic reading system and the barcode after printing for verification purposes using a reading system of the print verification station 23 so as to match the newly captured partial signature (by the reading system) against the partial reference signature reconstructed from the barcode during the substrate printing process;

The said first magneto optic reading system operates to capture and develop a digital representation (at the rate of 100 to 300 millisecond per deposit) having complex 3D signal structures; the said digital representations being stored in the data server of the system; the representation then being embedded in an encrypted format into a 2 D barcode / image (100-300 milliseconds per digital representation) and the said barcode / image being printed onto substrate for irrefutably linking both the particle deposit and its digital representation embedded onto the substrate.

Embodiments of the first and second reading system are depicted in Figures 6 and Figure 7. The said reading system reads, decodes and correlates partial magneto-optical reference signatures which are encoded in a barcode printed on the substrate itself. Matching with the partial reference signature is first carried out, and matching with the full reference signature is only required if the system cannot reliably determine authenticity from the partial reference signature.

The reading system operates in steps of:

- ✓ decoding of the barcode printed on the substrate 415 (such as currency);
- ✓ reconstructing partial reference signature from the said decoded barcode;
- ✓ detecting the said fiducial marks on the particulate based composition 400 and capturing a new magneto-optical signature from said particulate based composition;
- ✓ extracting another partial signature from the newly acquired signature by using the selected region information encoded in the barcode;
- ✓ matching the partial reference signature reconstructed from the barcode and the partial signature extracted from the newly acquired signature;
- ✓ decision of authenticity based on the extent of the said matching;
- ✓ optionally if the two partial signatures match cannot be reliably determined, retrieving the full reference signature from the database using the substrate serial number or other identifying information, and then matching the full reference signature from the database against the newly acquired full signature to determine whether the substrate is authenticated or fails.

In an embodiment of the present invention as depicted in Figure 6, a system 610 is used to first retain the substrate 415 such as currency which requires retrieval of the full

signature from the database to determine its authenticity. As depicted in Figure 6(b), the system comprises of 2D barcode scanner 601 and signature reading means 600. By placing such currency first in a holding apparatus through the input 603, the reading the reading system can continue to process subsequent currency in parallel, and not be
5 slowed down by retrieval of the full signature from the database.

Another embodiment of the present invention as depicted in Figure 7. It comprises of a barcode scanner 701 to read barcode 500 on the substrate and signature reading means 702 to read the particulate based composition 400 on the substrate. It reads
10 the particulate based composition and the barcode of one substrate such as currency note at a time manually. Such a reading system may be in the form of a table-top machine or a handheld reader suitable for establishments or individuals.

The said particulate based composition 400 comprises of magnetizable metal and / or
15 metal oxide particles, alkyd resins and water based acrylic emulsion. Alternatively the composition comprises metal / metal oxide particles and UV curable ink.

The selected water based acrylic emulsion and the UV cured ink contain appropriate binders, viscosity modifiers and stabilizers,

20 drying agents to ensure rapid drying and speedy surface skin formation after the composition is pressured deposited onto the substrate.

The composition preferably in the form of paste with apparent viscosity in the range of 2 to 10 Pas, the solid content is in the range of 50- 90% is pressured deposited onto
25 the substrate.

In one of the embodiments the said composition is prepared in steps of:

- ✓ Soaking metal particles /metal oxide (20 to 80% by weight) in Enamel (10% - 50% by weight) to impart the rust proof features, wherein the alkyd resin has specific
30 gravity 1 – 2.0 preferably 1.0 – 1.11,
- ✓ adding (10 to 70 % by weight) acrylic emulsion and mixing in a planetary mixer to form a paste wherein the acrylic emulsion has specific gravity of 1.2- 2.0 preferably 1.38 – 1.42,

When this composition is deposited on the substrate, heat curing of the deposited the deposited paste is carried out at 50 -200° C as the substrate (sheet/ roll) moves at 0.6 meter/sec to 5 meter/sec.

Enamels include but not restricted to solvent based Alkyd resins, epoxy, polyurethane, acrylics etc.

Alkyds include but not restricted to soyabean oil modified alkyds, long oil modified alkyds with the number average molecular weights of 2000 to 10000. Some of the ready to use alkyd paints are supplied by reputed brands in paint industries as Nippon, Akzo Nobel, Rustoleum, Nerolac, Asian Paints, ICI paints etc.

Acrylic emulsions are waterborne emulsions of polymers, not restricted to styrene/ vinyl based polymers with number average molecular weights 10000 to 1000000. Acrylic emulsions are also supplied ready to use by reputed brands as Nippon, Akzo Nobel, Rustoleum, Nerolac, Asian Paints, ICI paints etc.

In another embodiment of the invention the composition is prepared by

- ✓ mixing metal and/or metal oxide particles (20-80% by weight), metal mixing UV ink (10%-40% by weight) and UV ink (10 to 70% by weight) in a planetary mixer to form a paste.
- ✓ Metal mixing UV INK is UV curable ink that enhances the binding properties of metal particles to the UV ink that is acrylic oligomer mixture.

When this composition is deposited on the substrate, curing of deposited paste is carried out by UV of suitable light intensity depending on the speed of the moving substrate (sheet/roll) at 0.6 meter/sec to 5 meter/sec.

The acrylic emulsion is an acrylic oligomer mixture that acts as a binding agent for the metal particles to adhere and also to form a firm bond between the substrate preferably but not limited to paper. . Further this imparts the flexibility to the deposit so as to impart the crack and crumple resistance

The metal mixing UV INK is UV curable ink that enhances the binding of particles to the UV ink which is acrylic oligomer composition.

The polymer composition of uv inks includes but not restricted to the polyester acrylate oligomers, phenoxy ethyl acrylates, Isobornyl acrylates, polyurathanes, epoxy acrylates, methacrylates, 1,6 hexanediol di acrylates, glycol ether acrylates, photo initiators etc.

The number average molecular weight range is but not restricted to 1000 to 100000.

- 5 Ready to use uv inks are supplied by reputed UV screen printing ink suppliers as Norcote inc, DIC, Sun chemicals, Siegwerk etc.

UV inks used are commercially available uv inks supplied by reputed UV screen printing ink suppliers as Norcote inc, DIC, Sun chemicals, Siegwerk etc.

- 10 It is to be noted that the said compositions can be tailored as per the requirements in terms of viscosity, use of means of deposition/ application on the substrate, surface characteristics of the substrate etc.

In one of the embodiments the particulate deposition metal mixing ink composition comprises of

- 15 polymer mixture in the range of 10-25% by weight; Acrylate mixture in the range of 15 to 44% by weight,
1,6 hexanediol diacrylate in the range 5 to 20% by weight,
photoinitiator mixture in the range of 5 to 12% by weight,
glycol ether acrylate in the range of 15 to 40% by weight.
20 The specific gravity of the composition is in the range of 1.0-1.2. The curing condition for this ink composition is in the range of 200-400 Watt/cm.

In another embodiment the particulate deposition of UV ink comprises acrylated oligomer Mixture in the range of 25 to 72% by weight,

- 25 N- Vinyl-2 Pyrrolidone(NVP) in the range of 10 to 30% by weight,
acrylated monomer mixture in the range of 4 to 18% by weight,
2-phenoxyethanol acrylate in the range of 4 to 16% by weight,
photo Initiators in the range of 2 to 15% by weight,
carbon black in the range of 0.8 to 14% by weight.
30 The specific gravity of the composition is in the range of 1.0 to 1.6. The curing condition for this ink composition is in the range of 200-400 Watt/cm.

In one of the embodiments the magnetic particles may include a high coercivity material. An exemplary high coercivity material is a neodymium magnet comprising Nd, Fe and B. The magnetic particles may include a ferrimagnetic material, an antiferromagnetic material, a ferromagnetic material or domains of varying magnetic properties within a continuous material (including voids causing variable magnetic properties) and combinations thereof. The ferromagnetic material is selected from the group consisting of MnBi, CrTe, EuO, CrO₂, MnAs, Fe, Ni, Co, Gd, Dy, corresponding alloys and oxides of Fe, Ni, Co, Sm, Gd, Dy, and combinations thereof.

The composition is deposited on the substrate using an applicator system comprising screen printing (Flat bed/ Rotary screen printing) wherein the screen is preferably of hardened steel having tailored tapered apertures based on the area and amount to be deposited under pressure on the substrate to maintain deposition thickness of 50 to 150 microns wherein the apparent viscosity of the paste is 2 Pas to 10 Pas during the deposition process.

In another embodiment spot dispensing may also be used for the deposition of the composition on the substrate.

When a composition containing water based emulsion is deposited on the substrate, heat curing of the deposited paste is carried out at 50 -200° C as the substrate (sheet/roll) moves at 0.6 meter/sec to 5 meter/sec.

When a composition based on UV curable ink is deposited on the substrate, curing of deposited paste is carried out by UV of suitable light intensity depending upon the speed of movement of substrate as the substrate moves (sheet/roll) at 0.6 meter/sec to 5 meter/sec.

The particle composite depositions on the substrate are magnetized using strong magnetic fields provided for example by Grade 50 Neomax magnets.

Upon completion of the deposition and magnetization the substrate is processed in the said data capture system enables capture and processing of information / data

The data processing system comprising

- a data capturing system to capture, process and transform information / data, wherein the system comprises data capture station comprising readers to capture the unique information / signature from the deposit;
- a data-matrix printer to print covert UV ink wherein one or plurality of data-matrix images / barcodes are printed at predetermined locations on the substrate wherein each datamatrix barcode has a unique serial number; and
- Print verifier to capture and verify the barcode / image.

In one of the embodiments the said substrate is currency note. In another embodiment the substrate is selected from woven or non woven fibre.

The present invention is illustrated with non-limiting examples.

Example 1

A paper substrate was used to deposit the composition of the present invention and was tested for deposition robustness, affixation and effects of aging. The substrate was in the form of 600 mm x 600 mm sheets. The through put of the system was maintained at 3500 sheets per hour.

The prepared particulate compositions contained particles 50% by weight of metal particles (Nd: 10 - 20 ,B: 3 - 6, Fe: 87 - 74 % by weight of the composition) wherein the particle size distribution was

Particle size distribution (PSD)	Weight %	Total > 60 Mesh (250 x 250 μ m opening)	< 2 wt%
		Total > 80 Mesh (177 x 177 μ m opening)	< 30 wt%
		Total < 270 Mesh (53 x 53 μ m opening)	< 15 wt%

One set of samples were prepared using the above metals were mixed and soaked for 10 minutes with Alkyd enamel which is a solvent based anticorrosion agent with specific gravity 1.0-1.11 (10% by weight of the composition) to which a water based acrylic

emulsion with specific gravity 1.38- 1.42 (40 % by weight of the total composition) was added and mixed using a planetary mixer at (1000 rpm) to form a uniformly distributed paste. Apparent Viscosity of the paste was 6.5 Pas.

- 5 A second set of samples were prepared using the above metal mix and blended with 10% by weight of metal mixing ink of specific gravity 1.088 and 40% by weight of white UV ink of specific gravity 1.33 using a planetary mixer at 1000 - 2000 rpm to form a uniformly distributed paste of apparent viscosity of 3.48 Pas.

The magnetic properties of the pastes were:

Magnetic properties of the paste		
Residual Induction, Br	mT	915-935
Coercive force, H _{cb}	kA/m (KOe)	450
Intrinsic coercivity, H _{cj}	kA/m (KOe)	540-620
Energy energy, (BH) _{max}	kJ/m^3 (MGOe)	114-126

10 The two pastes were used to prepare set 1 (composition with water based acrylic emulsion) and set 2 test samples (composition based on metal mixing ink and UV ink).

15 The paste as mixed above was spread on the reciprocating screen (screen moves and squeegee stationary). The screen velocity was maintained at 0.6 to 1.0 meters per sec. The thickness of the paste was maintained between 50 -150 micron. An overlay of UV cured ink was printed on top of the paste print and cured under UV light (125 MJ/cm)). Further, Neomax 50 with field strength of 400kJ/m³ was used for magnetizing the cured paste.

20 Following tests were carried out on the set 1 and set 2 of prepared samples:

- ✓ Measure of affixation - The substrate was tested by using a rub proof tester- for 10000 cycles – 3.5 PSI pressure. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image and the matching results are shown in Figs 2.1(a) and 2.1(b) for samples of set1 and figs 3.1(a) and 3.1(a) two samples of set2.
- ✓ Laundry test - Test was performed using a 1 L reactor, comprising a mechanical stirrer, a heating mantle, containing 500 mL of water, 2.5 g of industrial laundry

powder and 5 g Na_2CO_3 . Three substrates were scanned and the samples were placed in the reactor, stirred and heated for 40 minutes at 95 deg C. Samples are washed using distilled water and dried for 2 hours at 40°C. The Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image and the representative matching results are shown in figs 2.2 for sample of set 1 and fig 3.2 for sample of set 2.

✓ Crumple test - Dry crumpling - Test were performed using a hollow cylinder and a solid rod of the matching diameter. First two notes were scanned. They were then rolled to make 15 mm diameter cylinder and inserted in the fixture. The fixture was closed with the piston and 100 N force was exerted for 5 mins. The notes were removed and scanned. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image and the representative matching results are shown in fig 2.3 for sample of Set 1 and fig 3.3 for sample of set 2.

✓ Wet crumpling – the substrate was damped in water for 10 minutes, wiped with a cotton cloth or tissue and then the same crumpling test is repeated as above. Magneto optic image of the fingerprint is captured and compared with the stored magneto optic image and the representative matching results are shown in 2.4 for sample of set 1 and fig 3.4 for sample of set 2.

✓ Accelerated aging test – The substrates / sheets were exposed the temp start from 150 for 1hr and test for the scan results. Scan results cold still match the original scan results. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image and the representative matching results are shown in fig. 2.5 for sample of set 1 and fig 3.5 for sample of set 2.

✓ The test methodology for matching the magneto optic image was as follows,

1. Bank note is inserted to the notes reader to obtain the information on the barcode and fingerprint label on the notes.
2. At this time a barcode scanner scans the data matrix barcode while a magneto-optic device will capture cross hair image and magnetic particle image simultaneously.
3. With this information, notes reader communicates with data base server to authenticate the note by comparing with the information on the note with the information that stored during registration.

4. If the information matched, the note is an authentic note.

Example 2

- 5 A woven cloth is used as a substrate deposit the composition of the present invention and was tested for deposition robustness, affixation and effects of aging. The substrate was in the form of roll of 600 mm width.

The composition of the deposit was maintained same as example 1.

- 10 The two pastes were used to prepare set 1 (composition with water based acrylic emulsion) and set 2 test samples (composition based on metal mixing ink and UV ink).

- The paste as mixed above was spread on the reciprocating screen (screen moves and squeegee stationary). The screen velocity was maintained at 0.6 to 1.0 meters per sec. The thickness of the paste was maintained between 50 -150 micron. An overlay of UV
15 cured ink was printed on top of the paste print and cured under UV light (125 Mj/cm)). Further, Neomax 50 with field strength of 400kJ/m^3 was used for magnetizing the cured paste.

Similar set of tests were carried out for as for example 1 as follows,

- 20 ✓ Measure of affixation - The substrate was tested by using a rub proof tester- for 10000 cycles – 3.5 PSI pressure. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.
- 25 ✓ Laundry test - Test was performed using a 1 L reactor, comprising a mechanical stirrer, a heating mantle, containing 500 mL of water, 2.5 g of industrial laundry powder and 5 g Na_2CO_3 . Three substrates were scanned and the samples were placed in the reactor, stirred and heated for 40 minutes at 95 deg C. Samples are washed using distilled water and dried for 2 hours at 40°C. The Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.
- 30 ✓ Crumple test - Dry crumpling - Test were performed using a hollow cylinder and a solid rod of the matching diameter. First two cloth pieces with the deposition were scanned. They were then rolled to make 15 mm diameter cylinder and inserted in the fixture. The fixture was closed with the piston and 100 N force was exerted

for 5 mins. The notes were removed and scanned. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image

- ✓ Wet crumpling – the substrate was damped in water for 10 minutes, wiped with a cotton cloth or tissue and then the same crumpling test is repeated as above. Magneto optic image of the fingerprint is captured and compared with the stored magneto optic image

- ✓ Accelerated aging test – The substrates were exposed the temp 125 deg C for 1hr and test for the scan results(Temperature for the woven cloth should be decided after exposing the substrate first so that the substrate should not blacken or burn). Scan results cold still match the original scan results. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image

- ✓ The test methodology for matching the magneto optic image was as follows,

1. Substrate piece with deposition is scanned using a handheld scanner device TX31 and the data is stored in database before starting the test.
2. At this time a barcode scanner scans the data matrix barcode while a magneto-optic device will capture cross hair image and magnetic particle image.
3. With this information, reader communicates with data base server to authenticate by comparing with the information on the substrate with the information that stored during registration.
4. Same scanning test is done after the tests mentioned as above.
5. If the information matched, the substrate piece is an authentic piece.

Example 3

A plastic film, white polyester 50 micron thickness, is used as a substrate deposit the composition of the present invention and was tested for deposition robustness, affixation and effects of aging. The substrate was in the form of roll of 600 mm width.

The composition of the deposit was maintained same as example 1.

The two pastes were used to prepare set 1 (composition with water based acrylic emulsion) and set 2 test samples (composition based on metal mixing ink and UV ink).

The paste as mixed above was spread on the reciprocating screen (screen moves and squeegee stationary). The screen velocity was maintained at 0.6 to 1.0 meters per sec. The thickness of the paste was maintained between 50 -150 micron. An overlay of UV cured ink was printed on top of the paste print and cured under UV light (125 MJ/cm²).
5 Further, Neomax 50 with field strength of 400kJ/m³ was used for magnetizing the cured paste.

Similar set of tests were carried out for as for example 1 as follows,

✓ Measure of affixation - The substrate was tested by using a rub proof tester- for
10 10000 cycles – 3.5 PSI pressure. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.

✓ Laundry test - Test was performed using a 1 L reactor, comprising a mechanical stirrer, a heating mantle, containing 500 mL of water, 2.5 g of industrial laundry powder and 5 g Na₂CO₃. Three substrates were scanned and the samples were
15 placed in the reactor, stirred and heated for 40 minutes at 95 deg C. Samples are washed using distilled water and dried for 2 hours at 40°C. The Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.

✓ Crumple test - Dry crumpling - Test were performed using a hollow cylinder and a
20 solid rod of the matching diameter. First two cloth pieces with the deposition were scanned. They were then rolled to make 15 mm diameter cylinder and inserted in the fixture. The fixture was closed with the piston and 100 N force was exerted for 5 mins. The notes were removed and scanned. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image

✓ Wet crumpling – the substrate was damped in water for 10 minutes, wiped with a
25 cotton cloth or tissue and then the same crumpling test is repeated as above. Magneto optic image of the fingerprint is captured and compared with the stored magneto optic image

✓ Accelerated aging test – The substrates were exposed the temp 125 deg C for
30 1hr and test for the scan results(Temperature for the woven cloth should be decided after exposing the substrate first so that the substrate should not blacken or burn). Scan results cold still match the original scan results. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image

✓ The test methodology for matching the magneto optic image was as follows,

1. Substrate piece with deposition is scanned using a handheld scanner device TX31 and the data is stored in database before starting the test.
2. At this time a barcode scanner scans the data matrix barcode while a magneto-optic device will capture cross hair image and magnetic particle image.
3. With this information, reader communicates with data base server to authenticate by comparing with the information on the substrate with the information that stored during registration.
4. Same scanning test is done after the tests mentioned as above.
5. If the information matched, the substrate piece is an authentic piece.

Example 4

A plastic film, white polyester 50 micron thickness, is used as a substrate deposit the composition of the present invention and was tested for deposition robustness, affixation and effects of aging. The substrate was in the form of roll of 600 mm width.

The composition of the deposit was maintained same as example 1.

The two pastes were used to prepare set 1 (composition with water based acrylic emulsion) and set 2 test samples (composition based on metal mixing ink and UV ink).

The different deposition method is used using a gravure printing technology.

The paste as mixed above was taken in a tray below the gravure roller of 50 -150 lines per inch with a design of the deposition required, engraved on the roller at required positions. The speed of the roller is maintained at 0.6 to 1.0 meters per sec. The thickness of the deposited paste was maintained between 50 -150 micron. An overlay of UV cured ink was printed on top of the paste print and cured under UV light (125 Mj/cm)). Further, Neomax 50 with field strength of 400kJ/m³ was used for magnetizing the cured paste.

Similar set of tests were carried out for as for example 1 as follows,

- ✓ Measure of affixation - The substrate was tested by using a rub proof tester- for 10000 cycles – 3.5 PSI pressure. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.

- ✓ Laundry test - Test was performed using a 1 L reactor, comprising a mechanical stirrer, a heating mantle, containing 500 mL of water, 2.5 g of industrial laundry powder and 5 g Na_2CO_3 . Three substrates were scanned and the samples were placed in the reactor, stirred and heated for 40 minutes at 95 deg C. Samples are washed using distilled water and dried for 2 hours at 40°C. The Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image.
- ✓ Crumple test - Dry crumpling - Test were performed using a hollow cylinder and a solid rod of the matching diameter. First two cloth pieces with the deposition were scanned. They were then rolled to make 15 mm diameter cylinder and inserted in the fixture. The fixture was closed with the piston and 100 N force was exerted for 5 mins. The notes were removed and scanned. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image
- ✓ Wet crumpling – the substrate was damped in water for 10 minutes, wiped with a cotton cloth or tissue and then the same crumpling test is repeated as above. Magneto optic image of the fingerprint is captured and compared with the stored magneto optic image
- ✓ Accelerated aging test – The substrates were exposed the temp 125 deg C for 1hr and test for the scan results(Temperature for the woven cloth should be decided after exposing the substrate first so that the substrate should not blacken or burn). Scan results cold still match the original scan results. Magneto optic image of the fingerprint was captured and compared with the stored magneto optic image
- ✓ The test methodology for matching the magneto optic image was as follows,
1. Substrate piece with deposition is scanned using a handheld scanner device TX31 and the data is stored in database before starting the test.
 2. At this time a barcode scanner scans the data matrix barcode while a magneto-optic device will capture cross hair image and magnetic particle image.
 3. With this information, reader communicates with data base server to authenticate by comparing with the information on the substrate with the information that stored during registration.
 4. Same scanning test is done after the tests mentioned as above.
 5. If the information matched, the substrate piece is an authentic piece.

It is evident from the present invention that the particulate composition of the present invention synergistically combined with the said applicator and data capture system enables deposition / application of the formulation / composition on the substrate on a mass scale yet maintaining precision of location of the identifier on the substrate, application of the identifier with respect to velocity of the substrate during production process, drying the deposited formulation in predetermined time and ensuring robustness of the deposited formulation during handling of the object and further enabling capturing digital signal of the deposited composition on the said substrate, store and embed the same in encrypted format to be further printed on the substrate as an associated identifier so as to create a dedicated , non repeatable unique functional digitised relation between the associated identifiers for specific object

We Claim

1. A clone proof document comprising
5 a substrate provided with a particulate composition as an identifier at a predetermined location,
barcode and/or image as an associated identifier
wherein there is a unique functional relation between two said identifiers of the substrate

10 wherein

the system for preparation and functionalization of the said substrate comprises of an applicator means (1) and a data capture system (2)

wherein the applicator system

15 a drying station (11),

a device to magnetize the composition on the substrate,

the data capture system (2) comprising a data capture centre (21)

comprising first magneto-optic reading system, data-matrix printing station

(22) and print verification station (23), a second reading device that is

20 deployed in the field for end-user

wherein

the said magneto-optic reading system captures the signal from the said particulate composition identifier of the said substrate and transforms it into a magneto-optical image to assign a signature to the said particulate based composition of the substrate,

25 the said signature is then embedded in an encrypted into a barcode / image as an associated identifier that is printed onto the substrate for irrefutably linking the said signature of the particulate deposit identifier with the associated identifier to create a unique functional relation between the said two identifiers.

- 30 2. A clone proof document as claimed in claim 1 is a security document, currency wherein the substrate is selected from woven or non-woven fibre.

3. A clone proof document and preparation system thereof as claimed in claim 1
35 wherein the said applicator system is selected from spot dispensing, flat bed screen printing (screen fixed and squeegee moves), flat bed screen printing

(screen moves and squeegee fixed), rotary screen printing for application / deposition of the composition / formulation on the substrate.

4. A clone proof document and preparation system thereof as claimed in claim 1
5 wherein the said drying station comprises of a means for curing of the deposited paste either by heat curing or by UV curing depending on the constituents of the medium of the particulate composition.

5. A clone proof document and preparation system thereof as claimed in claim 1
10 wherein process of assigning signature to the particulate based composition identifier is carried out in steps of:

✓ creating reference coordinate system during printing process of substrate
(415 (Figure 4) by printing fiducial marks on top of the applied particulate
based composition identifier (400) so that an origin and orientation can be
15 determined from the fiducial marks;

✓ capturing magneto-optical image from the particulate based composition
(400) with the aid of the said magneto-optic reading system (410);

✓ dividing the said image into multiple regions using the fiducial marks as a
coordinate system;

20 ✓ checking the said regions for magnetic field strength variation for explicit
signature creation;

✓ storing magneto-optical image in the said data capture system (2)
database as its full reference signature for particular substrate;

✓ creating a partial magneto-optical reference signature;

25 ✓ encryption of the said partial reference signature using AES 128 for
symmetric key encryption, or by using a public/private key pair if
asymmetric encryption is preferable;

✓ compressing and encoding the said partial reference signature into a
barcode (500 (Figure 5)) that is printed on the substrate (415);

30 wherein by reconstructing the partial reference signature from the barcode
(500) printed on the substrate (415) and matching against a newly
acquired magneto-optical signature, a reading system associated with the
present determines whether the two match or correlate without using the
full reference signature stored in the system database;

✓ reading the particulate based composition using magneto optic reading system and the barcode after printing for verification purposes using a reading system of the print verification station (23) so as to match the newly captured partial signature (by the reading system) against the partial reference signature reconstructed from the barcode during the substrate printing process.

6. A clone proof document and preparation system thereof as claimed in claim 4 wherein fiducial marks include: a cross-hair, square, rectangular, circular or linear marks or any combination of the above.

7. A clone proof document and preparation system thereof as claimed in claims 1, 5, 6 wherein the said magneto optic reading system operates to capture and develop a digital representation preferably at the rate in the range of 100 to 300 millisecond per deposit; the said representation then embedded in an encrypted format into a barcode / image at the rate in the range of 100-300 milliseconds per digital representation

wherein the said barcode / image is printed onto substrate for irrefutably linking both the particle deposit identifier and its digital representation embedded onto the substrate in the form of a barcode / image.

8. A clone proof document and preparation system thereof as claimed in claim 1 wherein the said magneto-optic reading system and the reading system to be used in the field reads, decodes and correlates partial magneto-optical reference signatures which are encoded in a barcode printed on the substrate itself

wherein matching with the partial reference signature is first carried out, and matching with the full reference signature is only required if the system cannot reliably determine authenticity from the partial reference signature.

9. A clone proof document and preparation system thereof as claimed in claims 1, 7, 8 wherein the said first and the second magneto-optic reading system to operates in steps of:

- ✓ decoding of the barcode printed on the substrate (415);
- ✓ reconstructing partial reference signature from the said decoded barcode;
- ✓ detecting the said fiducial marks on the particulate based composition (400) and capturing a new magneto-optical signature from said particulate based composition;
- ✓ extracting another partial signature from the newly acquired signature by using the selected region information encoded in the barcode;
- ✓ matching the partial reference signature reconstructed from the barcode and the partial signature extracted from the newly acquired signature;
- ✓ deciding of authenticity based on the extent of the said matching;
- ✓ optionally if the two partial signatures match cannot be reliably determined, retrieving the full reference signature from the database using the substrate serial number or other identifying information, and then matching the full reference signature from the database against the newly acquired full signature to determine whether the substrate is authenticated or fails.

10. A clone proof document and preparation system thereof as claimed in claims 1, 9 wherein the said second reading system comprises of barcode scanner (601) and signature reading means (600) wherein by placing the clone proof document first in a holding apparatus through the input (603), the reading can continue to process subsequent clone proof document in parallel, and not be slowed down by retrieval of the full signature from the database.
11. A clone proof document and preparation system thereof as claimed in claims 1, 9, 10 wherein the said second reading system comprises of a barcode scanner (701) to read barcode (500) on the substrate and signature reading means (702) to read the particulate based composition (400) on the substrate, it reads the particulate based composition identifier signature and the barcode of one substrate at a time manually wherein the reading device is in the form of a table-top machine or a handheld reader.

12. A clone proof document and preparation system thereof as claimed in claim 1 wherein the said particulate based composition of the identifier (400) comprises of magnetizable metal and / or metal oxide particles, alkyd resins and water based acrylic emulsion.
13. A clone proof document and preparation system thereof as claimed in claims 1, 12 wherein the said composition comprises metal / metal oxide particles and UV curable ink.
14. A clone proof document and preparation system thereof as claimed in claims 1, 12, 13 wherein the selected water based acrylic emulsion and the UV cured ink comprise of binders, viscosity modifiers and stabilizers, drying agents to ensure rapid drying and speedy surface skin formation after the composition is pressured deposited onto the substrate.
15. A clone proof document and preparation system thereof as claimed in claims 1, 12-14 wherein the said composition is in the form of paste with apparent viscosity in the range of 2 to 10 Pas, the solid content is in the range of 50- 90% that is pressured deposited onto the substrate.
16. A clone proof document and preparation system thereof as claimed in claims 1, 12-15 wherein the said composition is prepared and applied on the substrate in steps of:
- ✓ soaking metal particles /metal oxide in the range of 20 to 80% by weight in Enamel in the range of 10% - 50% by weight to impart the rust proof features, wherein the alkyd resin has specific gravity 1 – 2.0 preferably 1.0 – 1.11,
 - ✓ adding acrylic emulsion in the range of 10 to 70 % by weight and mixing in a planetary mixer to form a paste wherein the acrylic emulsion has specific gravity of 1.2- 2.0 preferably 1.38 – 1.42,
 - ✓ depositing the composition on the substrate,
 - ✓ heat curing of the deposited composition at 50 -200° C as the substrate moves with the velocity in the range of 0.6 meter/sec to 5 meter/sec.

17. A clone proof document and preparation system thereof as claimed in claims 1, 12-16 wherein enamels include solvent based Alkyd resins, epoxy, polyurethane, acrylics.
18. A clone proof document and preparation system thereof as claimed in claims 1, 12-17 wherein Alkyds include soyabean oil modified alkyds, long oil modified alkyds with the number average molecular weights of 2000 to 10000.
19. A clone proof document and preparation system thereof as claimed in claims 1, 12-18 wherein Acrylic emulsions are waterborne emulsions of polymers, not restricted to styrene/ vinyl based polymers with number average molecular weights 10000 to 1000000.
20. A clone proof document and preparation system thereof as claimed in claims 1, 12-19 wherein the said composition is prepared applied on the substrate in steps of:
- ✓ mixing metal and/or metal oxide particles in the range of 20-80% by weight, metal mixing UV ink in the range of 10%-40% by weight and UV ink in the range 10 to 70% by weight in a planetary mixer to form a paste;
 - ✓ metal mixing UV INK is UV curable ink that enhances the binding properties of metal particles to the UV ink that is acrylic oligomer mixture
 - ✓ depositing the composition on the substrate;
 - ✓ curing of deposited paste by UV wherein substrate is moved at the velocity of the range of 0.6 meter/sec to 5 meter/sec.
21. A clone proof document and preparation system thereof as claimed in claims 1, 12-20 wherein the acrylic emulsion is an acrylic oligomer mixture that acts as a binding agent for the metal particles to adhere and also to form a firm bond between the substrate, it imparts the flexibility to the deposit so as to impart the crack and crumple resistance
22. A clone proof document and preparation system thereof as claimed in claims 1, 12-21 wherein the metal mixing UV INK is UV curable ink that enhances the binding of particles to the UV ink which is acrylic oligomer composition.
23. A clone proof document and preparation system thereof as claimed in claims 1, 12-22 wherein the polymer composition of UV inks includes polyester acrylate

oligomers, phenoxy ethyl acrylates, Isobornyl acrylates, polyurathanes, epoxy acrylates, methacrylates, 1,6 hexanediol di acrylates, glycol ether acrylates, photo initiators wherein the number average molecular weight range is but not restricted to 1000 to 100000.

- 5 24. A clone proof document and preparation system thereof as claimed in claims 1, 12-23 wherein the particulate deposition identifier (400) metal mixing ink composition comprises of
polymer mixture in the range of 10-25% by weight; acrylate mixture in the range of 15 to 44% by weight,
10 1,6 hexanediol diacrylate in the range 5 to 20% by weight,
photoinitiator mixture in the range of 5 to 12% by weight,
glycol ether acrylate in the range of 15 to 40% by weight
wherein the specific gravity of the composition is in the range of 1.0-1.2;
wherein the curing condition for this ink composition is in the range of 200-400
15 Watt/cm.
25. A clone proof document and preparation system thereof as claimed in claims 1, 12-24 wherein the particulate deposition identifier (400) metal mixing ink composition comprises of In another embodiment the particulate deposition of
20 UV ink comprises
acrylated oligomer mixture in the range of 25 to 72% by weight,
N- Vinyl-2 Pyrrolidone(NVP) in the range of 10 to 30% by weight,
acrylated monomer mixture in the range of 4 to 18% by weight,
2-Phenoxyethanol acrylate in the range of 4 to 16% by weight,
25 photo Initiators in the range of 2 to 15% by weight,
carbon black in the range of 0.8 to 14% by weight.
wherein the specific gravity of the composition is in the range of 1.0 to 1.6.,
curing condition for this ink composition is in the range of 200-400 Watt/cm.
- 30 26. A clone proof document and preparation system thereof as claimed in claims 1, 12-25 wherein the magnetic particles include a high coercivity material such as neodymium magnet comprising Nd, Fe and B.

27. A clone proof document and preparation system thereof as claimed in claims 1, 12-26 wherein magnetic particles include a ferrimagnetic material, an antiferromagnetic material, a ferromagnetic material or domains of varying magnetic properties within a continuous material and combinations thereof
5 wherein the ferromagnetic material is selected from the group consisting of MnBi, CrTe, EuO, CrO₂, MnAs, Fe, Ni, Co, Gd, Dy, corresponding alloys and oxides of Fe, Ni, Co, Sm, Gd, Dy, and combinations thereof.

28. A clone proof document and preparation system thereof as claimed in claims 1-
10 27 wherein the said composition is deposited on the substrate using an applicator system comprising screen printing wherein the screen is preferably of hardened steel having tailored tapered apertures based on the area and amount to be deposited under pressure on the substrate to maintain deposition thickness in the range of 50 to 150 microns wherein the apparent viscosity of the paste is 2
15 Pa.s to 10 Pa.s during the deposition process.

29. A clone proof document and preparation system thereof as claimed in claims 1-28 wherein spot dispensing is used for the deposition of the said composition on the substrate.

30. A clone proof document and preparation system thereof as claimed in claims 1-29 wherein the composition containing water based emulsion is deposited on the substrate, heat curing of the deposited paste is carried out at 50 -200° C as the substrate moves with a velocity in the range of 0.6 meter/sec to 5 meter/sec.

31. A clone proof document and preparation system thereof as claimed in claims 1-29 wherein the composition based on UV curable ink is deposited on the
25 substrate wherein curing of deposited paste is carried out by UV of suitable light intensity, the substrate is displaced at a velocity in the range of 0.6 meter/sec to 5 meter/sec.

32. A clone proof document and preparation system thereof as claimed in claims 1-31 wherein the particle composite depositions on the substrate are magnetized
30 using strong magnetic fields generated by Grade 50 Neomax magnets.

33. A clone proof document comprising

a substrate provided with a particulate composition as an identifier at a predetermined location,
barcode and/or image as an associated identifier
wherein there is a unique functional relation between the two said identifiers of
5 the substrate.

34. A clone proof document comprising
a currency provided with a particulate composition as an identifier at a
predetermined location,
10 barcode and/or image as an associated identifier
wherein there is a unique functional relation between the two said identifiers of
the currency..

35. A clone proof document wherein
15 a system for preparation and functionalization of the said substrate comprises of
an applicator means (1) and a data capture system (2)
wherein the applicator system
a drying station (11),
a device to magnetize the ted composition on the substrate,
20 the data capture system (2) comprising a data capture centre (21) comprising
magneto-optic reading system, data-matrix printing station (22) and print
verification station (23), a reading device to be used in the field
wherein
the said magneto-optic reading system captures the signal from the said
25 particulate composition identifier of the said substrate and transforms it into an
magneto-optical image to assign a signature to the said particulate based
composition of the substrate,
the said signature is then embedded in an encrypted format into a barcode /
image as an associated identifier that is printed onto the substrate for irrefutably
30 linking the said signature of the particulate deposit identifier with the associated
identifier to create a unique functional relation between the said two identifiers.