"The structural microscopically analysis of the full color printers & copiers utilized in valuable secured prints counterfeiting crimes."

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Introduction:

In all cases of criminal offenses of all kinds and forms, the first task of the defense is accusing the inaccuracy & demurrer of the case procedures. Then the defense is accusing the **corruption** of the found or discovered evidences in the crime scene.

As all aspects of our lives have been developed and digitalized, the crime of counterfeiting ((simulation of the whole secured valuable print)) also has been developed and **digitalized**.

Daily billions of people deal with the secured valuable prints, on over their lives. Inside the wallet of any human being there's must be, at least, **one type of the valuable secured prints**. The valuable secured prints diversify backing to their securing strengthens and functional importance start of the transportation tickets and other prepaid tickets..... passing through the banknotes, certificates and licenses of all kinds and issuing purposes….. & end with the various types of travelling passports.

The technological revolution has made every home, office, factory, shop…&etc a **potential scene** of the crime of the digital counterfeiting (**digi-feiting**) crime. By possessing a digital scanner, personal computer & digital printing any citizen can build a **complete digital counterfeiting production flow**, in his house or his office. This digi-feiting flow consists of **three stations**: scanning or entering (digitalization) station, computer station for color retouching and information alteration & out-putting printing station.

The seizures (seized evidences) in the digital counterfeiting crimes scenes don't depart from those **six** varities:

1- An electronic **digital Scanner** creates the digital binary codes computer file of the desired valuable print.
2- A **personal computer** loaded with the scanning and processing of color and layout S\Ws.
3- One (or more) **digital copying or printing machine**, whatever its technology is (ink-jetting \ powder electrographic \ dye sublimation \ D2T2 \ …..&etc).
4- Blank (white) printing sheets.
5- All kinds of the printing machines' consumables; like inks & chemicals.
6- The finished digi-feited prints.

Claiming the **uncertainly** of the outputting relationship between the **seized digital printing machine** and the **digi-feited prints** is one of the most important defense strategies in digital counterfeiting crimes. Such these claims mean the **corruption** of the whole crime scene registered seizures (seized evidences), leading to the insured **innocence**!

Previous inspection methods:

Over **decades**, scientific studies and the image analytical laboratory researches haven't been stopped, aiming to **standardize linking** methods between the **digi-feited** valuable prints and **their creators** (out putters) of digital printing machines.

1 - The first of those linking methods was by the two scientists: **Chen and Oliver**. Here the digital microscopic analysis is used to prove the **similarity** between the **printed characters edges' defects** on the counterfeited print and the same characters when inspected on **fresh (just printed)** standards outputs from the digital printer seized in the crime scene.

2- Then the three scientists: **Thompson, Tchan and Manning** have innovated a method of inspection based also on the analysis of enlarged digital microscopic images, but with alternative reference comparison models.
The positions **co-ordinates**, **density variations** profiles & the surrounding **ink stains** geometrics of the printed characters' edges were applied as reference comparison models linking between the digital printer and its output.

The results of these both two methods **hadn't had static levels of certainty & credibility** on all models of digital printers. The same shortcoming happened on **different paper grades**; because the ink absorbency profile is different for each, so the microscopic structural characteristics of the printed characters on them will vary too. The **high liquidity ratio** in the inks' bases formulas of digital ink jetters is something which has the former same destructive effect on the microscopic characteristics.

3 - Then an inspection technique has the Latin shortcut idiomatic **ESDA** had been devised (ESDA = the proving using a static electricity precipitation or the electrostatic charges). This method depends on the analysis of the **visual effects image** caused by the pressure cylinders utilized in the feeding and delivery units of the B\W or four inks CMYK digital **electrographic** printers & copiers. These pressure cylinders are utilized also to drag and pull the paper sheet inside the digital color **ink jetters**. In ESDA inspection method, those pressure remarks are the reference comparison models linking between the digital printer and the digi-feited outputs.

The mechanism of ESDA method is based on charging the printed output sheet with a high- electrical voltage, and then a powdery ink with **opposite charge** is sprayed on the sheet. The entire sheet surface will pick up the ink powder except the **raised areas of the pressure loads** earlier described, which therefore could be easily visually characterized.

Comparatively with a **ballpoint pen writing loads**, the digital printers & copiers' pressure loads here appear **far weaker**. As well as, these pressure loads are rotary ones with **non- specific positions**. In addition, the strength of human fingers or handling pressures on the digi-feited prints can **erase** all of their ex-printing raised pressures. Those three parameters are the **main shortcomings** of ESDA method.

4 – After that and by the genius scientist **Mikkilineni**, a very revolutionary inspection technology was codified and described. This method is based on the electronic scanning followed by a comparatively mathematical analysis of the **micro lines & gaps** in the half-tone (not solid) areas on the **electrographic** digi-feited prints.

Those structural characteristics had been given the expression **(Bandings)**. Fortunately, each model of **electrographic** printers or copiers is **personalized** by its' outputs **different Bandings** lines and gaps.

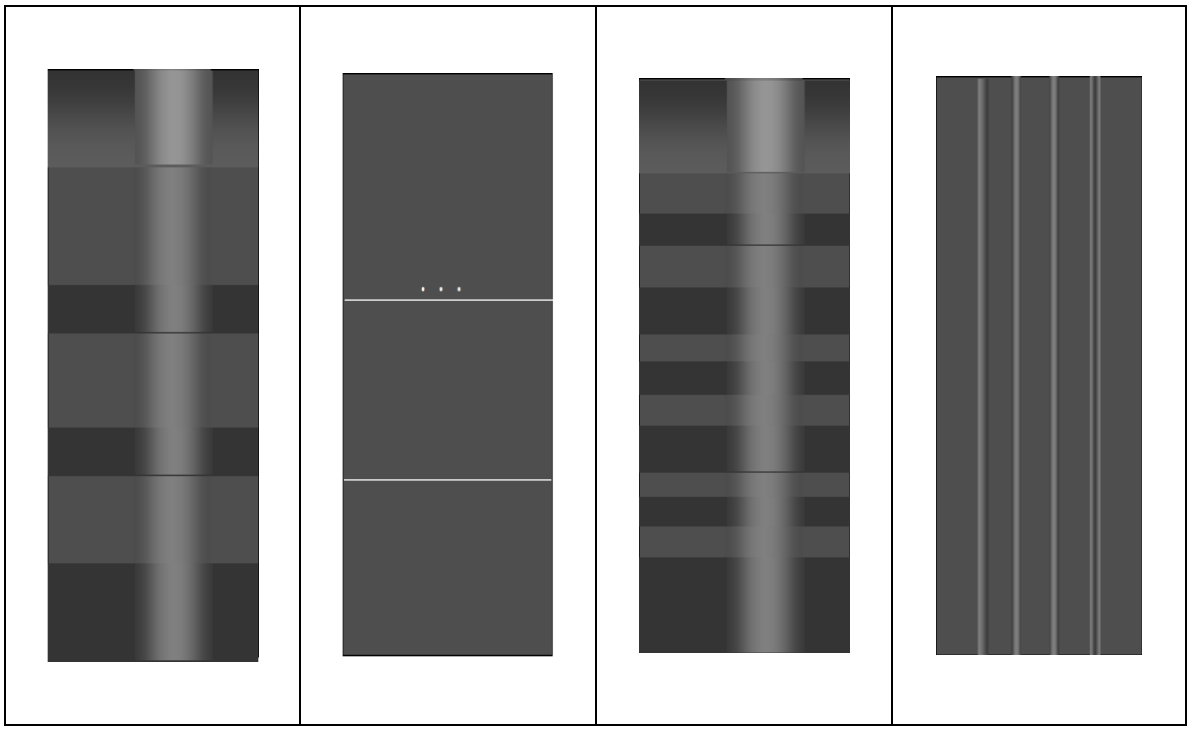


Fig (1): The Bandings micro clear different structural lines & gaps on the electrograph printers & copiers' outputs.

5 – In the year **2007**, a printing scientist's team work at the **London School of communication** in the United Kingdom had published his results of **developing** the Mikkilineni's Bandings electrograph digi-feited prints inspection method. The major development, was implementing a **too high-resolution** digital as an alternative of the ordinary electronic scanning.

After developing, also the **reference comparison models** linking between the output prints and the electrographic printers or copiers according to the Banding method **have been increased**. Now four new reference models are measured: the **un-evenness averages** of the half tones' densities, the **CIE $l^*a^*b^*$** color values, the characters' edges **sharpness** & the **dimensional co-ordinates** profiles on the electrographic digi-feited prints, as beside the pre-used structural characteristics of the Banding white gaps & lines.

The problem:

Where it is **impossible** to put a fixed standard analytical reference (Guide reference) based on the **chemical** analysis of the inks layers on the outputs' surfaces for almost all models of digital printers; that is because of the possibility of **re-filling** the inks' cartridges with non-genuine installations and components. So, it was necessary to resort to **non-chemical** inspection methods linking between the printed counterfeited documents and their digital creators (printers).

But For their part, also these non-chemical methods **suffer from shortcomings** put their repeatability, certainty & credibility profiles **away from** the standard ranges. The availability of an evidences inspection standard method is of imperative to **establish a commission direct charge** of the act of any crime, especially the valuable documents **digital computer counterfeiting crimes**.

The forensic science is in an **urgent need** to examine an innovative inspection technology of the digi-feited documents, which can **jump over** all the shortcomings & the diminished certainties of the old technologies.

The target:

Standardize a revolutionary visual inspection technology with **no uncertainty range** linking between the **digi-feited** color secured valuable prints and the **color printer or copier**, seized together within the digital counterfeiting crime scene.

This innovative visual technology based on the **inevitable differences** in the half-tone **dots structural** characteristics & the micro structural **dot patterns** on the outputs of **any** digital printer or copier comparing with **any other** printer or copier of different technology, or even between various models of the **same technology**.

The methodology:

This scientific article follows a **descriptive analytical methodology**, supported with explanatory graphs & schemes.

Technical definitions & abbreviations:

- The structural unit of the genuine secured valuable print: the **solid** 100% density monochrome **line**, with too infinite integrity & tight tolerances profiles of edges sharpness. Obtaining various densities values from **one ink**, on the genuine linear document, depending on the linear relationship between the densities and the printed **lines areas** (**frequency** or number per area) or the lines' **depths** on the printing plate (in the case of **gravure** printing technology).

- The digital scanner: the **first** station in the digital valuable secured document counterfeiting flow. Scanner is the **inputting** station which **digitalizes** the different optical reflected photon concentrations (spatial frequency of the photons) from the original genuine valuable document, for generating electrons fluxes with numbers parallel to the concentrations of the photons. Those electron fluxes, soon will be

translated into an encryption binary codes (zero \ 1) **digital file** of the **scanned valuable secured print**. In the future (while outputting) that file will play the driver role of the used digital printer or copier.

Fig (2): Flatbed digital scanner.

- A digital printing machine: the **third** station in the valuable secured document digital counterfeiting flow. The digital printer is the **inking creator or outputter** of the physical body of the counterfeited valuable secured document. The digital printer works under the **complete control** of the scanned valuable print binary codes (zero \ 1) digital file, which stored on the hard disk of a **personal computer** (the **second** station in the digital valuable secured document counterfeiting flow). The more **prevalent** digital printers' technologies are:

- The ink-jetters.
- The electrographic solid or liquid powdery ink printers.
- The dye sublimation printers.
- The Dye Diffusion Thermal Transfer \ D2T2.

- **Digital Copier:** containing a scanner digitalizes the original genuine valuable document into a digital file, and then completes its working mechanism **exactly as a digital printer**.

- The crime of counterfeiting (or imitation or simulation) a valuable secured print: the unauthorized **total creation** of the valuable secured print, with its whole **three components** (i.e. physical body, securing devices & information carriers), and of course with in part or in full **false information**. Whether accomplished with traditional **analog or digital** printing or copying techniques.

- The crime of forgery: the partially or wholly **informative tampering** (removal & (or) addition & (or) change) of information carried on the valuable secured document. Whatever the **production or carrying techniques** varieties for this information is: handwriting, typewriting, digital printing, laser burning, one-dimension or two-dimensions barcode & carrying on a magnetic tapes or optical memory tapes or contact microchip or RFID contactless microchip.

And whatever the **reading method** of the carried information is, whether **analog** understandable human reading feedback or **digital de-coding** of the encoded information by the **OCV** (scanning + S\W processing) technology or by the digital multi technologies **terminals** (readers).

- The crime of digifeiting: the unauthorized **total creation** of the valuable secured print, accomplished across a three stations full digital work flow.

- **Inputting** station: a digital scanner,
- A **P.C Processing** station of color, design:
- One or more digital printer or copier of any technology works as an outputting station.

- Electrographic digital printer \ or copier: here, the **laser arrays** under the control of the scanned valuable print binary codes (zero \ 1) digital file, are working **to erase** the electrical charges in the non-printing areas of the surface of the printing (inking) drum. The printing drum is manufactured of electrically semiconductor Selenium. The still charged areas (the printing areas) **pick up ink powder balls** with opposite electric charge whether in mono black color, or in full CMYK colors. The ink balls are **transmitted** to the paper by pressure loads and **fused** by heat.

Fig (3): Models of powder electrographic digital printers. (Left) A monochrome printer. (Right) Four-color printer.

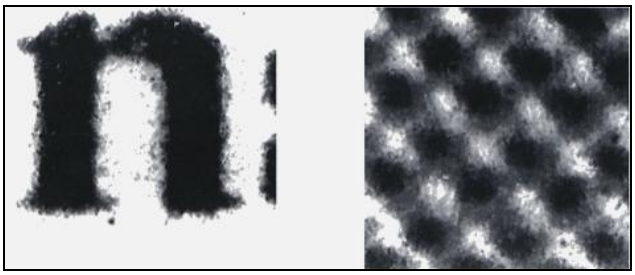


Fig (4): (Left) The structural microscopic inspection of single solid color (B\W) text characters copied on a digital electrographic copier, implies the large areas of the surrounding ink powder halos. (Right) Microscopic inspection of single half-tone color (B\W) dots printed by a digital electrographic printer.

- B\W: monochrome printing or copying with just one black ink **(Black \ White)**.

- CMYK processes inks: transparent four color printing inks **(cyan C \ magenta M \ yellow Y \ Black K, or B)**. Theoretically, and bowing to an overlapping mechanism of printed CMYK dot-matrix **different**

in: area profiles (**AM** screening), spatial frequency (**FM** screening) or both (**hybrid** screening), **all** the optical **visible spectrum hues** (hundreds of thousands) could be reproduced.

- CIE $l^*a^*b^*$ color system: an imagined **spherical simulation model** of all the optical visible spectrum hues (hundreds of thousands), has been developed by the International Commission of Lightening \ CIE in the year **1976**. The Sphere is based on: the **Red \ green** axis (the a^* axis) with numerical extension of (- 80 to +120) and the **Blue \ yellow** axis (the b^* axis) with the same (- 80 to +120) numerical extension. In addition to **centered** axis (the l^* axis), which represents the hues lighting degrees with numerical extension of (zero to +120).

- Ink jetting digital printer: here, the **ink emitters** (jetters of micro pipes with **one fixed** diameter) under the control of the scanned valuable print binary codes (zero \ 1) digital file will **drop down** adjacent CMYK ink droplets. The droplets are in **one fixed** micro diameter or **various** diameters (in the case of **repeated** jetting on the same position co-ordinates on the printed sheet).

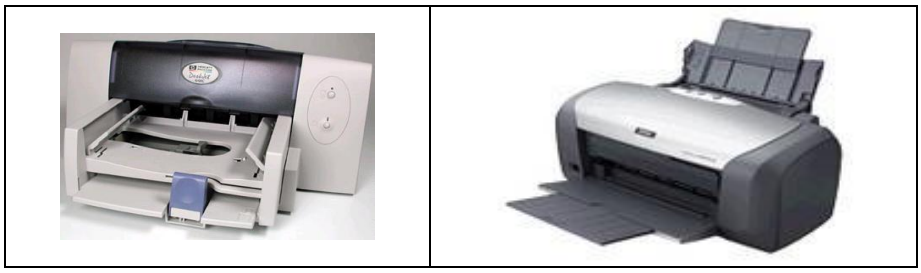


Fig (5): Models of inkjet digital printers.

- Thermal transfer digital printer: here, the **mechanical heads** with **one fixed** diameter & a static **high temperature** degree (or the **laser arrays)** will **transfer** the inks dots from four plastic tapes coated with dyes of the four basic color CMYK to the printed paper sheet surface, that's is done under complete control of the scanned valuable print binary codes (zero \ 1) digital file. The CMYK dots are in **one fixed** diameter or **various** diameters (if the **laser thermal transferring** is applied).

- D2T2 Digital Printer: D2T2 is the abbreviation of **D**ye **D**iffusion **T**hermal **T**ransfer. The D2T2 printer represents the **latest generation** of thermal transfer printers, and works with the same mechanism, but through **intermediate stage** where the CMYK droplets **evaporate** to be **re-intensified** and restore their liquid nature to dry on the printed paper sheet surface.

Characterization of the digital printers outputs properties:

The **following tables** include adequately descriptions supported by the graphic representation.....

Table ((1)): The genuine valuable secured print - inspection results.

The optical inspection properties	The printing structural unit	The microscopic structure
The description	Solid line **(100% color strength)**, in **infinite** profiles of sharpness & details **integrity**. These lines are **Impossible** to be reproduced, but only by the conventional analog (too expensive machines) printing techniques.	Various values profiles of the printed lines' space **areas**, **spatial frequencies** & color **saturation** (Note: color saturation α etching depth, only on **gravure** printing cylinders).

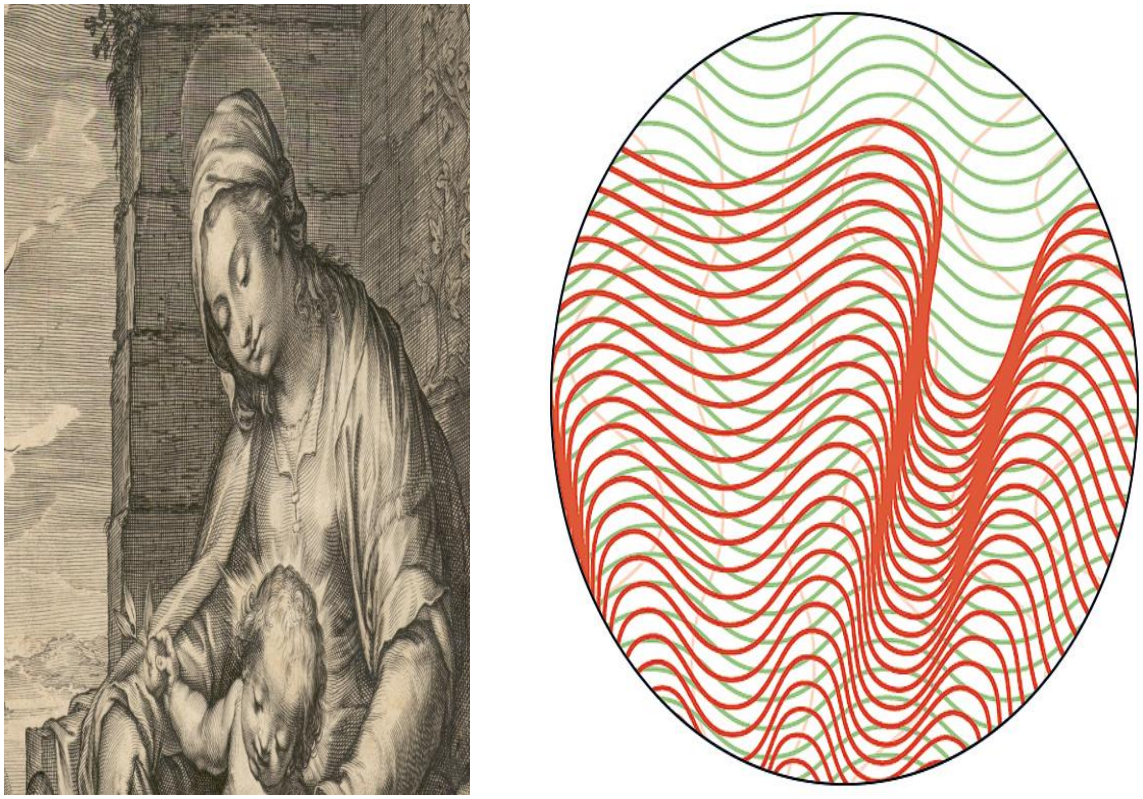


Fig (6): The linear printing structural unit of the genuine secured valuable print.

Table ((2)): The Ink jet digital printers' outputs - inspection results.

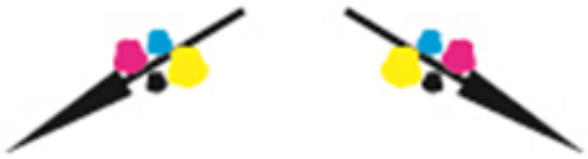
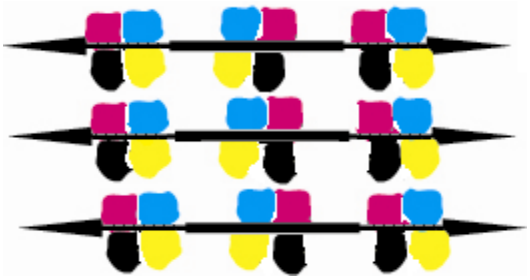
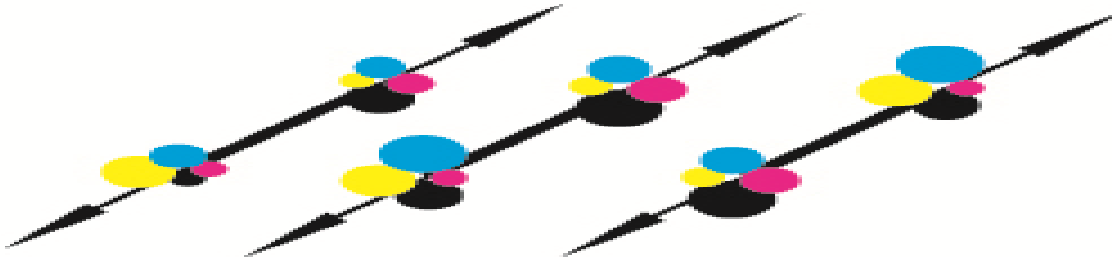
<table>
<tr><td>The optical inspection properties
The digital printing technique</td><td colspan="2">The printing structural unit</td><td>The microscopic structure</td></tr>
<tr><td rowspan="4">Digital ink jet printers.</td><td rowspan="4">One fixed micro diameter CMYK halftone dots, with too poor sharpness & integrity profiles. The dots spatial frequency profile is variable.</td><td rowspan="4">Various micro diameters CMYK halftone dots, with too poor sharpness & integrity profiles. The dots thickness & spatial frequency profiles are variable.</td><td>Adjacent <u>various</u> diameters dots in <u>random</u> various directions.</td></tr>
<tr><td>OR: adjacent <u>one fixed</u> diameter dots in <u>random</u> various directions.</td></tr>
<tr><td>OR: adjacent <u>various</u> diameters dots in <u>one horizontal</u> direction with static intervals.</td></tr>
<tr><td>OR: adjacent <u>One fixed</u> diameter dots in <u>one horizontal</u> direction with static intervals.</td></tr>
<tr><td colspan="4">The graphic pattern simulation of the microscopic structure</td></tr>
<tr><td colspan="2">Fixed diameter
  </td><td colspan="2">Various diameters
  </td></tr>
<tr><td colspan="2">Fixed diameter
  </td><td colspan="2">Various diameters
  </td></tr>
</table>

Table ((3)): The Electrographic digital printers & copiers' outputs - inspection results.

<table>
<tr><td>The optical inspection properties
The digital printing technique</td><td>The printing structural unit</td><td>The microscopic structure</td></tr>
<tr><td rowspan="2">Digital Electrog-raphic printers & copiers.</td><td rowspan="2">Various micro diameters CMYK halftone dots, with too high sharpness & integrity profiles compared with the ink jetting & D2T2 dots. The minimum dots thickness profile > the minimum ink jetting halftone dot diameter. The halftone dots spatial frequency profile is variable.</td><td>The copiers
Overlapped <u>various</u> diameters dots in <u>one vertical</u> direction with static intervals.</td></tr>
<tr><td>The printers
Overlapped <u>various</u> diameters dots in <u>one diagonal</u> direction with static intervals.</td></tr>
<tr><td colspan="3">The graphic pattern simulation of the microscopic structure</td></tr>
<tr><td colspan="3">Electrographic Copiers
  </td></tr>
<tr><td colspan="3">Electrographic Printers
  </td></tr>
</table>

Table ((3)): The <u>Thermal Transfer & D2T2</u> digital printers & copiers' outputs - inspection results.

The optical inspection properties / The digital printing technique	The printing structural unit		The microscopic structure
Dye Diffusion Thermal Transfer\ D2T2 printers.	**(mechanical heads printers)** **One fixed** micro diameter CMYK halftone dots, with **good** sharpness & integrity profiles. The dots **spatial frequency** profile is **variable**.	**(laser arrays printers)** **Various** micro diameters CMYK halftone dots, with **good** sharpness & integrity profiles. The dots **spatial frequency** profile is **variable**.	**Overlapped <u>one fixed</u>** diameter dots in **<u>one diagonal</u>** direction with static intervals.
			Overlapped <u>various</u> diameters dots in **<u>one diagonal</u>** direction with static intervals.
The graphic pattern simulation of the microscopic structure			
Fixed diameter 			
Various diameter 			

Research results:

1- Setting an innovative scheduled characterization (clarified by graphic illustrations) of the **inkjet digital** printers out-puts' micro-structural parameters, with their **random** or **parallel horizontal** directions patterns of the **static or various** diameters **adjacent** CMYK colors dots.

2- Setting an innovative scheduled characterization (clarified by with graphic illustrations) of the **electrographic (laser) copier printers** out-puts' micro-structural parameters, with their **parallel vertical** directions patterns of the **various** diameters **overlapped** CMYK colors dots. And similarly, of the **electrographic (laser) digital printer**, with their out-putting dots' **parallel diagonal** directions.

3- Setting an innovative scheduled characterization (clarified by with graphic illustrations) of the **thermal transfer & D2T2** digital printers out-puts' micro-structural parameters, with their **parallel vertical** or **diagonal** directions patterns of the **static or various** diameters **overlapped** CMYK colors dots.

Research recommendations:

The research recommends that……

1- The inspection techniques (both chemical \ and those which based on the compression signs on the print's edges) used to link the counterfeited valuable prints with its digital printer seized together in the digital counterfeit crime scene and which all suffer from insufficient evidential certainty, **should be avoided.**

2- The forensic counterfeiting experts should apply the suggested tables published in this research as a **probative technical reference guide** with a **zero** scale variation; as they depend on a **personalized** micro-structural characterizations **differ for every** digital printer technology used as an outputting station of digi-feited valuable prints.

References:

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Abstract:

*This research dealt with the **shortcomings** of multiple causes which wide the standard tolerances' bands of evidential credibility and certainty for all the methods (whether chemical or electrostatic and others) used for **linking** the **counterfeited** valuable secured prints with their **creators** of various technologies **digital printers**.*

*This research aimed to **specify** an **innovative** optical microscopic inspection technology with **too high certainty level**, proving the **origination link** between the counterfeited print and its digital printer; that's because it relies on the **insured variations** of the **structural** units' **parameters** on digital printers' outputs.*

*This research followed an in detailed **descriptive analytical** methodology subsidized with innovative graphic illustrations & resulted in setting three **(unpublished before)** scheduled **characterizations of the out-puts' micro-structural parameters** for the four major digital printing technologies: the ink jetting, the powder electrographic (laser printers & copiers), the thermal transfer & the D2T2.*