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1. Learning Outcomes

After studying this module, you shall be able to know about-

- ESDA, its features, uses and applications
- VSC, its features, uses and applications

2. Introduction

In addition to various types of microscopes like magnifying lens, compound microscope, stereo microscope and comparison microscope that are being used for the analysis of questioned documents. Some instruments such as Electrostatic Detection Apparatus (ESDA) and Video Spectral Comparator (VSC) are also used for the analysis of the documents that are in question. These instruments are only meant for document analysis. ESDA is a forensic device used to detect indented writings in paper. VSC combines sophisticated digital imaging and multi-wavelength LED technology with a clear and efficient software interface, to provide a complete solution to the examination of all questioned documents.

3. Electrostatic Detection Apparatus

ESDA is an electrostatic detection device that is a specialized apparatus regularly used for questioned document analysis to decipher indentations or impressions in paper. It is a non-destructive technique. It is a sensitive technique capable of detecting indentations or impressions or sub-surface writings created on pages which are several layers beneath the top-most sheet. It is also sensitive to the writings that were created many years back because of which indentations were made. It is a device used to visualize indented writing, which is a type of evidence which may be encountered during questioned document analysis in the cases of ransom note and extortion letters.

Indented writing

Indented writing is a writing that is formed to a sheet of paper underneath the one on which the original writing was done. For example, if someone writes something on the top sheet of a notepad, the pressure exerted by the pen or pencil is sufficient to indent the papers beneath. Indented writings are the partially visible depressions on a sheet of paper that was underneath the one on which the visible writing was made while it was being written on. Such depressions are formed due to the application of pressure by the writing instrument during the process of writing. For example, the indented writing would appear as a carbon copy of the top sheet if carbon paper has been inserted between the pages. Indented writings have proved to be valuable evidence in some cases during investigation. For example, the top sheet of a bookmaker's records may have been removed and destroyed, but it is still possible to determine what was written on the sheet by the impressions left on the pad. These impressions may contain convicting evidences supporting the charge of illegal gambling activities, etc. When paper is studied under oblique or side lighting, its indented impressions are often visible and readable.

ESDA takes advantage of the technology used in copying machines and laser printers to help visualize the indented writing. A sheet of thin plastic is placed over the paper that has the suspected indented writing, and both are placed in a vacuum chamber. A charge of static electricity is imparted to the plastic, and then toner powder is applied to the surface of the plastic. An image of the indented writing will be created on the plastic, with the added advantage that the original paper is not altered or damaged. ESDA methods can also be used to lift footprints in dust.

Figure1: Electrostatic Detection Apparatus

History of the Technique

Rather Seward in 1998 and 1999 proposed a theory explaining the detection capability of an Electrostatic Detection Device (EDD) due to the surface charge effect created by paper-to-paper friction especially in the area wherever a writing instrument is pressed down into the uppermost sheet of paper. Seward's model was based on charge transport through the Mylar-paper-platen structure and is called the charge transport model.

Principle of the Technique

This technique is based on the theory that the paper sandwiched between grounded platen and Mylar charging film acted as a capacitor with the change in capacitance due to differing compression of paper. This led to models like "Thickness Variation Theory" and "Surface Variation Theory"

Components of ESDA:

1. Main Unit
2. Reel holder (Imaging film)
3. Corona Wand
4. Mains power adapter

Implementation of ESDA consists of the following steps:

1. The document is humidified.
2. The document is placed on a porous, electrically earthen platen so that it is drawn down by the action of a vacuum pump. A length of thin, transparent imaging film is placed over the document to completely cover it.
3. Negative electrical charge is deposited onto the upper surface of the imaging film using the hand- held corona wand.
4. The operator waits for a short time while an electrostatic image forms on the imaging film. The nature of this electrostatic image is determined by the latent image of surface irregularities on the document.
5. The electrostatic image is developed and made visible by applying negatively-charged black toner powder to the imaging film. The resulting ESDA image is therefore a life-size pattern of toner particles that are bonded to those regions of the imaging film where the electrostatic image presents an effective positive charge.
6. The ESDA image is made permanent by laminating the imaging film with a sheet of adhesive fixing film.
7. The laminated ESDA image is removed for the further examination, leaving the original document unaffected.

Practical Use

- **Evaluation of Material:**

1. **Sufficient material for examination**: An electrostatic detection device works most excellent when a solo sheet of smooth paper, i.e. without wrinkles, folds, creases or stains are used. Heavyweight, coated or treated papers give poor results. The age of the document is not a factor of concern in this examination. Invisible indentation has been developed on documents older than 50 years.

2. **Examination using oblique/ Side lighting:** As a general rule all the documents should be examined using side lighting. This is significant as they may detect deep indentations which sometimes electrostatic detection device may fail to decipher properly.

3. Documents that have been subjected to high levels of humidity will not generally retain indentations. As a result, other forensic examinations involving the wetting of a document, such as fingerprint development using a ninhydrin solution, should not be done until after examination for indentations.

Preparation of Apparatus

1. **Humidify**-: Electrostatic Detection Apparatus depends on the relative humidity of the environment. If the ambient relative humidity is less than 60% than document humidification is required and if the ambient relative humidity is greater than 60% than document humidification is not required. Extreme humidification can destroy the document. Maintaining appropriate humidity in the chamber is an important step to preserve the document and avoiding it from getting wet.

2. **Control Sample**-: When the performance of the apparatus is required to be checked. The control sample is to be kept along with the questioned document sample for the comparison of results.

It may be possible that the apparatus does not decipher the indentations so in such case result can be seen on control sample as well. If the indentations are present on control sample but not on questioned it means questioned document does not have sufficient indentation to get deciphered. It also means that apparatus is working properly.

Arrangement of platen-: The questioned sample is placed on top of the flat platen surface and has some space on platen to allow the film to charge.

1. Nature of document: - Electrostatic detection apparatus works on solo sheet of legal sized paper mostly second sheet is taken to decipher indentation because it is replica of original handwriting. I would also like to mention that the deep or heavy indented writing on a page should not be taken for examination because ESDA fails to decipher deep indentations, so that time we can take third or fourth sheet of document for examination because it will have normal indentations and can be deciphered by ESDA.

2. Imaging film-: Imaging film should cover document properly and touch the platen all around the document. Imaging film has two purposes first to develop electrostatic charge and second to develop any invisible indentation on the document. Also take care to avoid excessive stretching of the film.

3. Charging of the Surface-: It is one of the processes in deciphering indentations. The hand-held unit i.e. a high corona wire is used for electrostatic charge in this process. The corona wand creates charge on the document and also changes charge to negative on paper. Since toner powder is negatively charged, after the charge has been developed on the surface/ paper, toner powder gets attracted to the paper and develops indentation by sticking to the paper.

4. **Toner to develop indentation**-: The electrostatic detection apparatus to visualize sub surface writings uses block toner powder. The variations in the charge of the surface and depending on the negative charged toner particles, they are attracted to the indentation writings on the paper. Once static charge has been applied to the film, the sub surface writing will be developed.

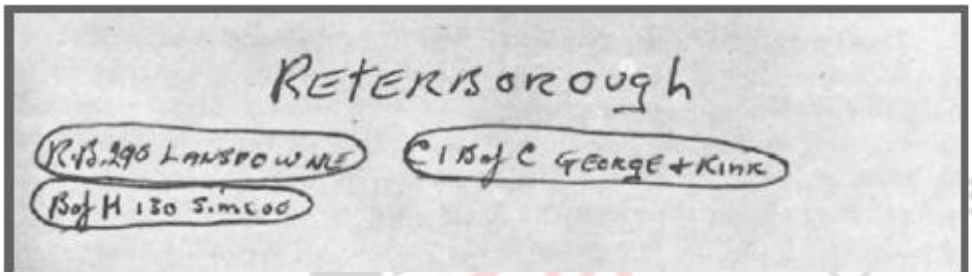
5. Preservation of results: After the development of indentation writing, it is important to record the results. The result can be recorded using the following methods:

- **Adhesive lift method**: The sheet or fixing paper is used to record the deciphered indentation. Fixing film is relatively a rigid sheet which is self- adhesive. The transparent polymer film is removed from backing material and cautiously fixing film is kept over the charged film. Pressure is applied carefully to fix the film by smaller roller then create sandwich so as to easily lift. After the lifting, the examiner observes developed indentation before making visible markings on the develop indentation paper.

- **SLR Photography**: After development of the indentation writing on document then it should be preserved by using photography for legal purposes. Take the pictures/ photographs with scale for the purpose of court.

- **Scanning Process**: We can save our results using scanning process and preserve it for future perspective.

    a. **Original writing**



    b. **Indentation develop by ESDA**

Factors Influencing The Quality Of Final Image By ESDA

1. Document Humidification
2. Paper Type: Paper has a very variable composition and differences in the basic raw materials, chemical treatment, impregnation or surface finish will generally affect both the contrast and degree of background development in the image.

Applications of Electrostatic Detection Device

Questioned document Examination

- ✓ **Cheque Forgery**-: In this category of forgery, possibility of cheque book in the hands of awful people can be there. The person can forge the signature on cheque and withdraw the money. In such a case we can examine second cheque for any indentations present.

- ✓ **Traced Forgery**-: Traced forgery can be done by tracing signature or handwriting impressed on second page. The forger will follow the pattern of indentation of signature or handwriting to forge the signature or handwriting of someone. In this case deciphering of traced forgery can be done using ESDA.

- ✓ **Ransom note** existence can be determined from the source of indentations by deciphering it on another piece of paper (culprit's notepad) in case written.

- ✓ **An anonymous letter** may bear impressions of writings that relate to some everyday activity of the offender which can ultimately lead an investigator to a particular suspect.

4. Video Spectral Comparator

It is designed to meet the requirements of immigration authorities, government agencies and forensic science laboratories. The VSC includes advanced features for the examination, comparison and authentication of documents including passports and travel documents, official letters and breeder documents, banknotes and cheques, works of art and valuable artifacts through the detection of irregularities.

Video Spectral comparator comprises of the following:

(a) Laser Induced Breakdown Spectrometer
(b) Computer
(c) Monitor

VSC is an integrated composite system comprising of cameras, various light sources which includes IR, Laser, UV etc. and filters which assist in comparison of questioned documents.

Features: VSC is a comprehensive work station and case work management system for document examiners featuring following:

1. **Hi Fi Imaging Technology:** An optical system that minimizes spatial distortions and chromatic aberration throughout the entire magnification range offering excellent image quality.

2. **High Resolution Imaging System**

3. **Full Range Light Source:** Includes incident and transmitted ultraviolet to infrared plus high intensity illumination for the examination of Infrared Florescence of inks.

4. **Graphic User Interface:** Innate, on screen control system allows the operator to navigate the system more easily. Magnification, light sources, filters, image analysis and image processing functions are selected from simple on screen icons using mouse.

5. **Multiple Laser Images (MLI):** MLI and changeable Laser Images can be viewed using the VSC's side lights. Alternatively the VSC range of hologram imaging LED's can be used giving great flexibility.

6. **Latent Images:** A new software feature, a digital imaging filter that detects and enhances latent security images on documents.

7. **Intelligent software:** VSC ensures compatible combination of illumination and imaging filter automatically.

8. **OVI Imaging**: An optical viewer that create images of OVI print from two angles incident at 45º, simultaneously.

9. **Image comparison**: A range of facilities for displaying images of two documents simultaneously including split screen, overlay and alternate strobe.

10. **Microspectrometer**: A high resolution real time grating spectrometer provides absorption, reflectance, transmittance and fluorescence spectra.

11. **Image integration**: A variation in the IR fluorescence emitted by two inks provides a valuable means of detecting a fraudulent alteration to the document.

12. **ICAO Data Reader**: The OCR allows operations to check data in the machine readable zone of passports and ID cards.

13. **Areas of Interest Processing**: By selecting restricted area of an image, the effects of image enhancement can be improved.

14. **Bar code Reader Deciphers**: 1D and 2D Bar codes including PDF417 format.

15. **Image Measurement**: A software module that enables examiner to make a variety of measurement including distances, angles, areas, circle radii and shape perimeters. A simple calibration procedure also enables absolute values to be computed.

16. **Birefringent security Features:** A circular polarizer will image security features printed with chiral birefringent pigment which appears to contrast against the background under the polarizer.

17. **Color measurement:** Characterizes the color of a selected area of an image in standard color coordinates for comparison.

18. **Image enhancement** with pseudo color mapping

19. **Invisible information decoders**

20. **Image processing and enhancement**

21. **Programmed examinations**

22. **Hyper spectral imaging**

VSC updated software is integrated with the document database system (with single user license) that enables the operator to generate their own database and to access and display data from the Keesing reference database of security documents. Keesing is a reference database of security documents (i.e.) Passports, ID cards, Driving licenses from 180 countries, comprising images and data.

VSC is one of the latest system incorporating advanced technology and integrated system in the field of questioned documents. It is a highly versatile system.

Visual spectral comparator is a comprehensive digital imaging system providing the questioned document examiner with an extensive range of facilities for detecting irregularities on altered and counterfeit documents.

VSC is a comprehensive digital imaging system combining high resolution optics and multi-spectral illumination with a powerful software package that includes tools for image enhancement and decoding digitally encrypted data. Access to optional reference databases enables comparisons with authentic security documents.

Specifications in VSC

- **Digital Imaging**
  - High resolution scientific grade digital camera
  - Zoom magnification range of approximately x1.5 to x170 (+/- 6%) on the standard 75cm (30inch) display monitor

- **KEY SOFTWARE FEATURES INCLUDE:**
  - Complete control of VSC system hardware
  - Image processing, comparison and analysis
  - Hyper pectoral imaging module
  - Seamless integration with Document and Banknote databases
  - Comprehensive casework management
  - Automated examination routines
  - Interactive tutorial

- **SET UP OF VSC 6000**

  - The VSC consists of a main unit and a PC-system. The main unit is, as one can see in figure a square box with 3 flaps. In the main unit one has a high resolution CCD fire wire color camera with sensitivity from 360 nm to 1100 nm, different light sources, and optical filters as well as a trans-light panel.
  - The panel is situated in the center of the document platen. Underneath the panel are light sources which can illuminate the document from below.

The document platen in itself is 650 mm x 650 mm while the trans-light panel is 235 mm x 175 mm. In the VSC there is also a high resolution grating spectrometer.

- This can analyze light from a small region in the document. As part of the VSC machinery is a 30 inches screen and a PC system which is Windows-based.

Fig.2 The VSC main unit is seen on the left and the screen is seen on the right.

❖ LIGHT SOURCES AND THEIR USES

- The VSC has four different light sources. These are used to help bring out specific types of features in the document examined.
- The first light source is incandescent filament lamps. These have a range from 400 nm-1000 nm and encompass visible and IR light. These lights are used in the VSC when one uses the functions of flood, transmitted, spot and side lighting.

- The LED lamps which have a wavelength from 400-700 nm are used with coaxial lighting and diffracted lighting. The UV lamps are Vapor discharge tubes.
- The VSC offers three ranges of UV light. This is with 365 nm (UV-A), 312 nm (UV-B) and 254 (UV-C) peak wavelengths. All of these can illuminate the document from above. With transmitted lighting the VSC only offers UV light with 365 nm.
- The last of the light sources is a flash tube. This lamp has a range of 850-1100 nm and is used for the Anti-Stokes flash function.

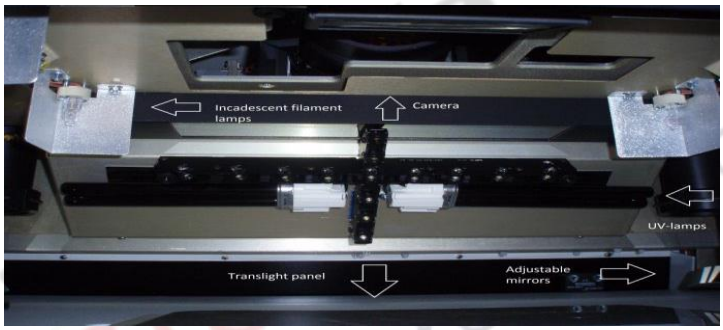


Fig.3 Inside the VSC main unit. The localization of the camera, two light sources, adjustable mirror and the trans-light panel is marked

❖ SOURCES OF LIGHT

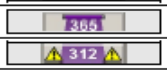
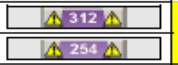
VSC®6000: Light sources				
Wavelength (nm)	Lamp type	Electrical power	Control feature	Illumination mode
400 – 1000 Visible + IR		2 x 5 W		Background lighting
		4 x 20 W		Flood lighting
		2 x 1 W		
		4 x 12 W		Transmitted lighting
		1 x 250 W		Narrowband spot lighting
		1 x 100 W		Spot lighting
				Tuneable spot lighting
		1 x 20 W		Transmitted spot lighting
		2 x 20 W		Side lighting
400 – 700 Visible		11 x 1 W		Coaxial lighting
		14 x 1 W		Diffracted lighting
365 UV-A		2 x 9 W		Transmitted UV lighting
		4 x 9 W		Ultraviolet lighting
312 UV-B		2 x 8 W		⚠ Ultraviolet lighting
254 UV-C		2 x 8 W		
850 –1100 IR				Anti-Stokes flash

Figure 4: Different sources of light

- A function which uses narrow-band illumination to excite fluorescence. This illumination is in the IR region above 800 nm and lack visible light. The VSC offers three different kinds of transmitted light. These light sources are located underneath the translight panel. Here transmitted UV light or transmitted broad band illumination illuminates either the entire panel or a single spot.
- Diffracted lighting is a function which illuminates the document from different directions, and is usually used to see Optically Variable Devices (OVD).
- The side lighting is also a broad band-illumination. There are two lamps, one on the left hand side and one on the right hand side of the document platen. These can be used separately or they can both be on at the same time.

- Coaxial light is another function the VSC offers. Coaxial light is a light that is shown perpendicularly on the document. Coaxial light reveals retro-reflective features in security documents, which are often used to prevent forgeries. Such retro-reflective features are invisible under normal light but revealed when the incident light is precisely coaxial to the angle of view.
- The VSC also has a filter control panel. With this the filters to be used in the camera and the spot lamp while using different functions can be chosen. This can determine if the whole range of the incandescent lamps of 400 nm-1000 nm will be measured, if only the visible light range will be let through the filter, or the operator can choose specific cut-off wavelengths.

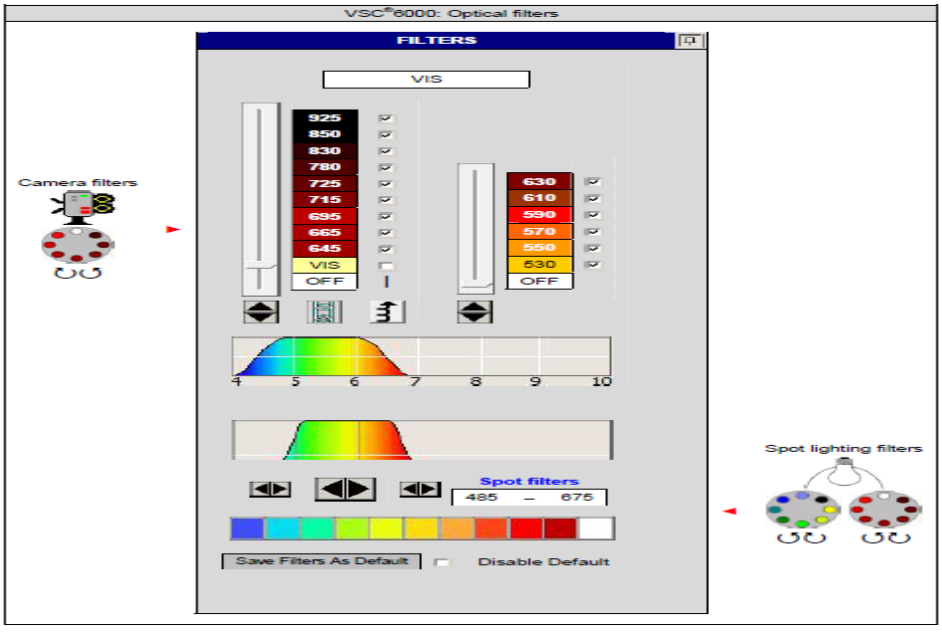


Figure 5: Filter control panel

- There is also a function where the VSC applies a sequence of camera filters in turn. This can be used, for instance, to see when a change, like fading, happens in the image. When using certain functions, the VSC can recommend suitable camera filters to be used.

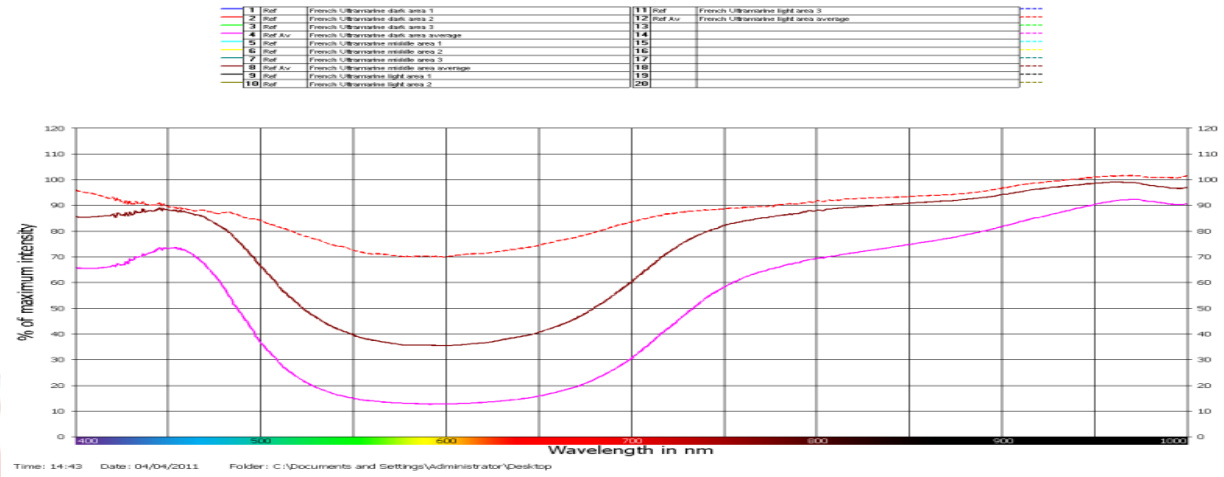


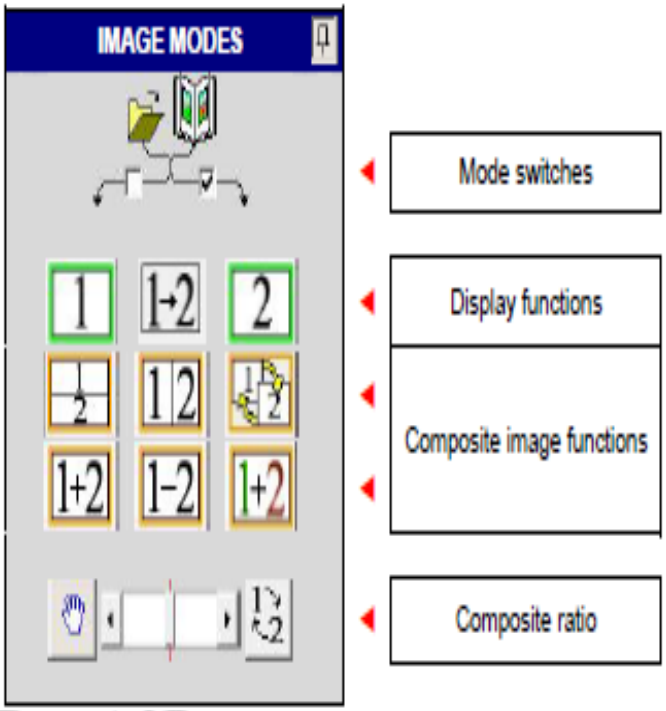
Figure 6: Spectral graphs of French Ultramarine. Here only the averages are shown. Above it one can see which graph has which color

❖ . SPECTRUM SCREEN

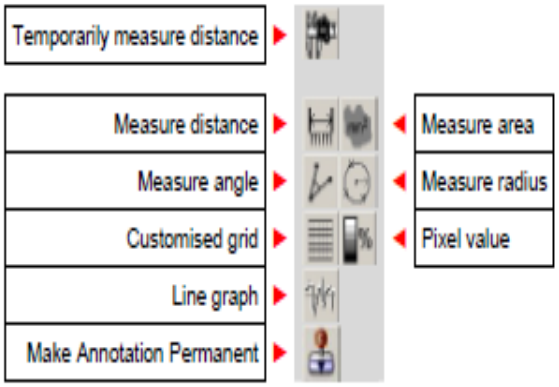
- The VSC offers microspectometry with a resolution of up to 9 nm. The spectrum screen (fig 5 and 6) shows a chromaticity chart and a spectral graph after a spectrum has been recorded. In the spectral graphs one can read the plots of light intensity versus the wavelength from 400-1000 nm. At most there can be 20 graphs at one time. There is also a list above the spectrum where one can input textual data of a specific graph and also decide on the color of the different graphs.

❖ **VARIOUS TOOLBARS IN VSC**

- **IMAGE BAR**



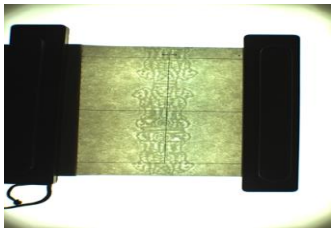
- **MEASUREMENT BAR**



❖ **APPLICATIONS**

- **Reveal Latent Images and Watermark:**

★ Latent images and watermarks are a commonly used security feature on banknotes worldwide. A latent image is visible only when viewed at an acute angle under reflected light and watermark is viewed under transmitted light.



★ **Anti Strokes Illuminator**

★ **Examining UV activated security features**

VSC is designed for the visual examination of Questioned Documents and Security Documents. Its applications are as under:

1. Used by immigration authorities and forensic laboratories.
2. Effective on all types of passports and identity cards.
3. Detects alterations and counterfeits.
4. Reveals covert security features.
5. Provides documentary evidence for prosecutions.
6. Helps generate security alerts.
7. Maintains comprehensive passport and bank note reference databases.

5. Summary

- Electrostatic Detection Apparatus (ESDA) and Video Spectral Comparator (VSC) are used for the analysis of the documents that are in question.
- ESDA is an electrostatic detection device that is a specialized apparatus regularly used for questioned document analysis to decipher indentations or impressions in paper.

- It is a non-destructive and sensitive technique.
- This technique is based on the theory that the paper sandwiched between grounded platen and Mylar charging film acted as a capacitor with the change in capacitance due to differing compression of paper.
- The application of ESDA includes detection of Cheques Forgery, Traced Forgery, and Ransom note, an anonymous letters.
- VSC is designed to meet the requirements of immigration authorities, government agencies and forensic science laboratories
- VSC is an integrated composite system comprising of cameras, various light sources which includes IR, Laser, UV etc. and filters which assist in comparison of questioned documents.
- VSC is designed for the visual examination of Questioned Documents and Security Documents.