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EXAMINATION OF INDIAN CURRENCY BY USING RAMAN SPECTROSCOPY

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***Abstract*—with the advanced technology, counterfeiters have improved their skills to effectively produce banknotes and have been reported around the world. To solve this problem, this study used forensic analysis techniques. In this study, Raman spectroscopy was discovered as an analytical method for study the effectiveness of Raman on authentic banknote. The original 500 banknote was analyzed by Raman spectroscope without sample preparation and five different regions were selected to study the front and back of the banknote. In this study, all results from all areas based on the original Indian 500 note survey became available and the reliability of the results was also calculated. This micro spectroscopic Raman technology provides fast, non-destructive and robust analysis using handheld equipment and is also very useful for the investigation and future use of counterfeit banknotes, making it an ideal method for the forensic community.**

***Keywords*— Raman Micro spectroscopy, Counterfeit, Indian Currency, forensicex amination.**

I. INTRODUCTION

Rapid advancement in printing and scanning technologies has simplified the task of creating fake documents. Creating counterfeit currency, especially high denomination notes, is on the rise. To find the solution of this problem we have forensic analysis methods. The forensic analysis of banknotes generally aims to answer questions regarding their authenticity, and several security features to make them easy to recognize and difficult to counterfeit. Forensic analytical science generally demands the use of instrumental techniques that do not require sample preparation. Raman micro spectroscopy offers high flexibility, a good chemical and structural specificity, high spatial resolution, and short acquisition times for analysis and is used in a nondestructive and minimally invasive manner. These characteristics, together with the availability of ‘‘low cost’’ portable instruments that only need a few seconds to record an acceptable spectrum in terms of signal to-noise ratio, and that allow rapid identification of samples, make Raman spectroscopy an excellent tool for forensic studies of the banknotes. [1-3]

Raman Spectroscopy

It's a non-destructive chemical analysis technique that gives you a lot of information on chemical structure, phase and polymorphy, crystallinity, and molecular interactions. It is a clever mix of optical confocal microscopy and is based on the interaction of light with chemical bonds inside a substance. It was discovered by Sir C. V. Raman.

A Raman spectrum contains a series of peaks that represent the strength and wavelength location of Raman scattered light, with each peak corresponding to a distinct chemical bond vibration, such as C-C, C=C, N-O, C-H, and so on. Raman is important in a variety of fields, including education and medicine, because to the inexpensive cost of optical microscopes. It & #39; s a quick procedure that usually just takes a few minutes. [4]

Currency

Currency is a medium of exchange for goods and services. Currency is paper or coin money that is frequently issued by governments and accepted as payment at face value. There are 180 UN-recognized national currencies in existence today, according to WorldAtlas.com. Another 66 countries use the dollar or have their currencies directly tied to it. The majority of countries print their own currency. The Swiss franc is Switzerland & #39;s official currency, while the Indian rupee is India & #39;s official currency Indian Currency. The Indian currency is also called the Indian Rupee (INR), and the coin is called Paisa. is the symbol of Indian Rupee. The design is similar to both the Devanagari letter "\" (ra) and the Latin capital letter "R". Indian banknotes are currently issued in 10 rupees, 20 rupees, 50 rupees, 100 rupees, 200 rupees, 500 rupees and 2000 rupees. These banknotes are called banknotes because they are issued by the Reserve Bank of India (RBI). Reserve Banks issue in 19 cities Chennai, Guwahati, Hyderabad, Jaipur, Jammu, Kanpur, Kolkata, Lakhnow, Mumbai, Nagpur, New Delhi, Patna, Thiruvananthapuram, Ahmedabad, Bangalore, Belapur, Bhopal, Bhuvneshwar. An extensive network of currency chests and currency chests in Chandigarh and Kochi. These offices receive new banknotes from the banknote printing press. The RBI issuing office will send new banknotes to the designated commercial bank branch. Below are the Security features and specifications given by Reserve Bank of India (RBI) for 500 denomination. The new 500 note

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with new security features was introduced into the banking system in November, 2016 after the old one was scrapped. [5] The rest of the paper is organized as follows. Material and methodology are explained in section II. Result and Discussion are presented in section III. Conclusion is given in section IV.

II. MATERIAL AND METHODOLOGY

A. SAMPLING–

The genuine currency of 500 was provided by the State Bank of India. For Raman micro spectroscopy there is no need to prepare sample.

B. SAMPLEUSE--

Genuine Indian 500 bank note was analyzed by using Raman Micro spectroscopy. Different areas and features were studied in this.

C. EQUIPMENT–

The Raman Microscope (Renishaw inVia) which was provided by CFC Center of Shivaji University (Kolhapur, Maharashtra, India) used for the Forensic examination of Indian currency (500). At 532-nm emission line of He Ne leaser (50mw) spectra were obtained. X50 objective lens used for the collection of scattered radiation and Raman spectra was collected by using the highly sensitive CCD (Charge-coupled device) camera. Also taken microscopic images of some specific point at X10.

A]List of the areas of the bank note

Sr. No.	Sample code	Sample	Position
1.	P1	Mahatma Gandhi's right eye	Frontside
2.	P2	Security thread	FrontSide
3.	P3	Mahatma Gandhi's Neck	Frontside
4.	P4	Denomination innumerals with rupee symbol	Frontsideatr ightdown side
5.	P5	Latentimage of the denomination	Frontsideleftd ownside

B]List of areas of microscopic view

Sr. No.	Samplec ode	Sample	Position
1.	M1	Circle withRs.500	Extreme right side atabovetheAshoka pillar
2.	M2	AshokchakraofIn dian flag	Backside(Redfort withIndianflag)

III. EXPERIMENT AND RESULT

In this study Raman Micro spectroscopy was used on the different characteristics and parts of genuine Indian (500) currency.

A1. Analysis of Mahatma Gandh i& #39;s right eye (P1)
Figure 1 show the Raman Spectra for a P1 sample, which range from 100 to 3200cm-1. For the intensity of leaser 0.05, the exposure time is 10 seconds. The pick wavelength for the P1 sample was 1598nm-1.

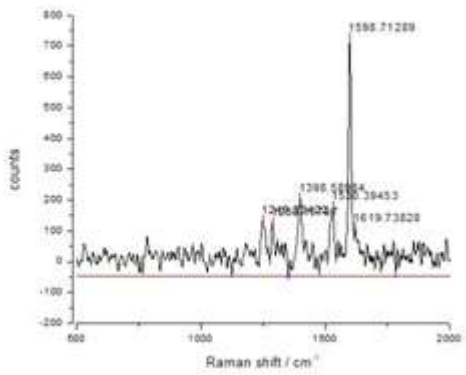

Fig.1.Raman spectra of the Mahatma Gandhi portrait (Eye) (P1)

A2. Analysis of Security thread (P2)
The Raman Spectra for the provided material is obtained in the range of 100 to 20,000cm-1, as shown in Figure 3. For the intensity of leaser 0.05, the exposure time is 30 seconds.

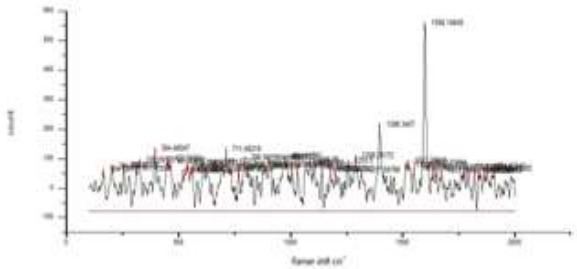

Fig.2.Ramanspectra of Security thread (P2)

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A3. Analysis of Mahatma Gandhi portrait Neck (P3)
The P3 sample Raman Spectra varies from 100 to 20,000 cm-1. The exposure time for intensity of leaser 1 is 10 seconds. The
P3 sample & #39;s optimal wavelength was 1598nm-1 Analysis of the rupee symbol and its denomination in numbers (P3).

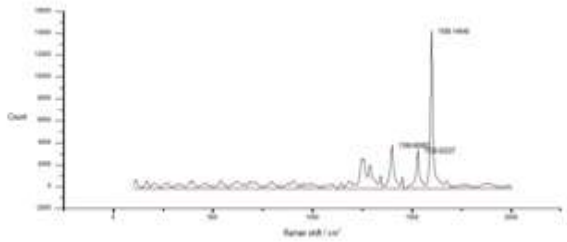

Fig.3.Raman spectra of Mahatma Gandhi portrait (Neck) (P3)

A4. Analysis of the rupee symbol and its denomination in numbers (P4)

The P4 sample's Raman Spectra varies from 100 to 20,000cm-1. For the intensity of leaser 0.05, the exposure time is 10 seconds. 1598nm-1 was the optimum wave length for the P4 sample.

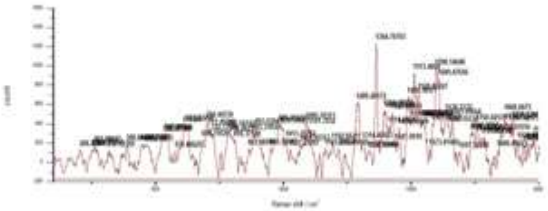

Fig. 4. Raman spectra of Denomination in numerals with rupee symbol (P4)

A5. Analysis of Latent image of the denomination (P5)
The Raman Spectra of the P5 sample ranges from 100 to 20,000 cm-1. The 10 & #39; s exposure time is for the intensity of leaser 0.05.
The pick wavelength for the P5 sample was 1598nm-1.

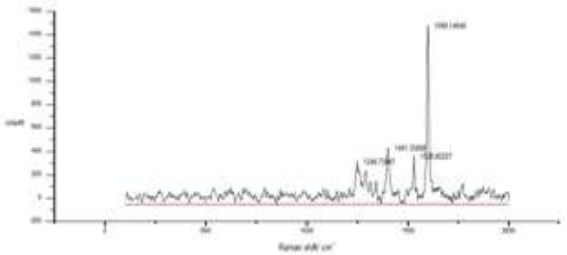

Fig.5.Raman spectra of Latentimage of the denomination (P5)

Table-Experiment Result

Sr. No.	**Sample Code**	**Intensity of laser m/s**	**Peak$_{nm}$-1**
1.	P1	0.05	1598.71
2.	P2	0.05	1599.14
3.	P3	1	1598.14
4.	P4	0.05	1598
5.	P5	0.05	1598

The picks 1598nm-1, 1599nm-1, 1598nm-1, 1598nm-1, 1598nm- 1 are the energy which is emitted by electron at the certain
wavelength. Similarly the paper which is made by cotton and linen fiber it also shows the vibration at a 532nm. The currency
note consists of green color shades which are fluorescence ink and that are Raman active. Green fluorescence ink emitted the
electron at the 1598nm -1 to 1599nm -1 when 1 to 0.05 m/s intensity of laser was given for 10 seconds.
From the above, measurements were made using Raman spectroscope with 532nm leaser of 50 mW. Each spectrum presented is an average exposure time of 10 seconds when the intensity varies from 1 to 0.05. The measurement range was selected based on various security features of the banknote. Due to the small spot size of the laser beam, we were able to select a very specific area. Only qualitative analysis of the spectrum was performed and not all safety features were measured.

Microscopic view

Fig.6. Micro scopic view of Circle with Rs.500 (M1)

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Fig.7. Micro scopic view of Circle with Rs.500 (M1)

IV. CONCLUSION

This work is based on the effectiveness of Raman Micro spectroscopy in the forensic examination of banknotes. The spectroscopic view of different part of authentic (Rs.500) banknote allows us the complementary study of classical forensic inspection by non-destructive technique. The common Raman spectra were found in between 1598cm-1 to 1599cm-1 in different areas of banknote. This research will be very helpful in various government agencies like banks, forensic science laboratory, legal authority's currency exchanges office and many private organizations and differentiating between the authentic and fake currency.

V. ACKNOWLEDGEMENT

The instrument for Raman Micro spectroscopy was provided by CFC center Shivaji University and the authentic banknote by SBI (Aurangabad) on which we have performed the Raman Micro spectroscopy.

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