9th International Conference on NDT of Art, Jerusalem Israel, 25-30 May 2008
For more papers of this publication click: www.ndt.net/search/docs.php3?MainSource=65

DETERMINING THE SEQUENCE OF CROSSING LINES USING FLUORESCENCE MICROSCOPY

Avner Rosengarten, Tanya Zhidkov
Israel Forensic Science Institute POB 131, Tzur Hadassah 99875, Israel

ABSTRACT
The determining of the sequence of crossing lines is one of the most challenging problems in forensic examination of documents. Optical examination, ESDA and lifting techniques, SEM [4], AFM [3], and laser profilometry [2] are used in order in order to determine the sequence of crossing lines. Currently there is not a general solution for this problem. This study presents the possibility of using fluorescence microscopy in order to determine the sequence of crossing lines. The study focused in cases of intersection between inkjet printer line and pen ink line. The results show that ink originated from a printer and ink originated from a pen can be optically separated. This separation allows the examiner to determine the sequence by simple measuring of the focus under the microscope.

INTRODUCTION
Determination of the sequence of crossing lines consists of several possibilities considering the crossing lines:
1. crossing lines of the same pen or the same printer using the same color;
2. crossing lines of different pens or printers using the same color;
3. crossing lines of different pens or printers using different colors;
4. crossing lines of pen and printer.

The majority of forensic cases are of the type of the three later.

In order to determine the sequence of crossing lines, a separation of the lines must be obtained. Separation can be achieved by morphological comparison of inks [3, 4], morphological analysis of the paper [2], or spectroscopic comparison of inks [1]. In most of forensic cases the document's condition does not allow an accurate examination of paper morphology. In addition morphological analysis of paper is uncertain in many cases [2].

The depth of ink dispersion from a ball point pen is 4-10μm, and the depth of ink dispersion from a printer is 7-8 μm. Thus spectroscopic separation by means of IR is limited and sometimes even impossible.

Most of inkjet printers have fluorescent ink, and most of pen inks do not fluoresce. Therefore fluorescence microscopy can be used for determination the sequence of crossing lines.

MATERIALS AND METHODS
The crossing lines were produced on plain paper. Three HP printers (G85, 3325, 920C), and five ball point pens (numbered 1-5) were used for producing the crossing lines. The crossing lines were examined by Olympus BX60 microscope with two sets of filters: excitation filter at 420-440 or 460-490nm and emission cut off filter at 475 or 515nm respectively. Photographs were taken at a magnification of X200. For determining the sequence of crossing lines, a single fiber contains the two types of inks was chosen.

RESULTS AND DISCUSSION
All types of printer's ink fluoresced at the experiment conditions. Ball point ink number 5 fluoresced at one of the filters set conditions. Since the fluorescence color of ball point ink is

different from that of printer ink, they can be distinguished and the sequence of their crossing lines can be determined. Fig. 1 shows ball point ink No. 5 above printer ink at fluorescent conditions for the pen ink.

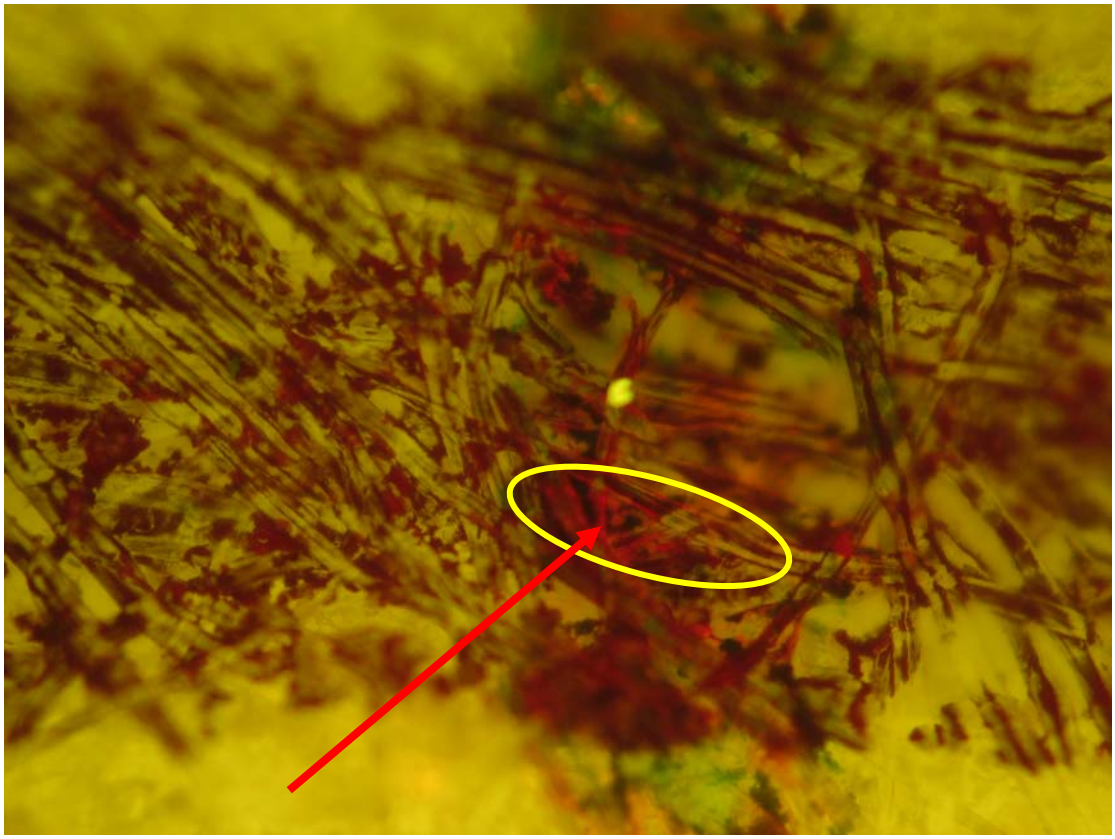

Fig 1: ball point ink No. 5 above printer ink (7μm difference)

Once separation by means of fluorescence achieved, the problem of determination the sequence of crossing lines is reduced to identification of both colors on the same fiber, and fine tuning of the focusing ladder solves the problem (Fig. 2, Fig. 3)

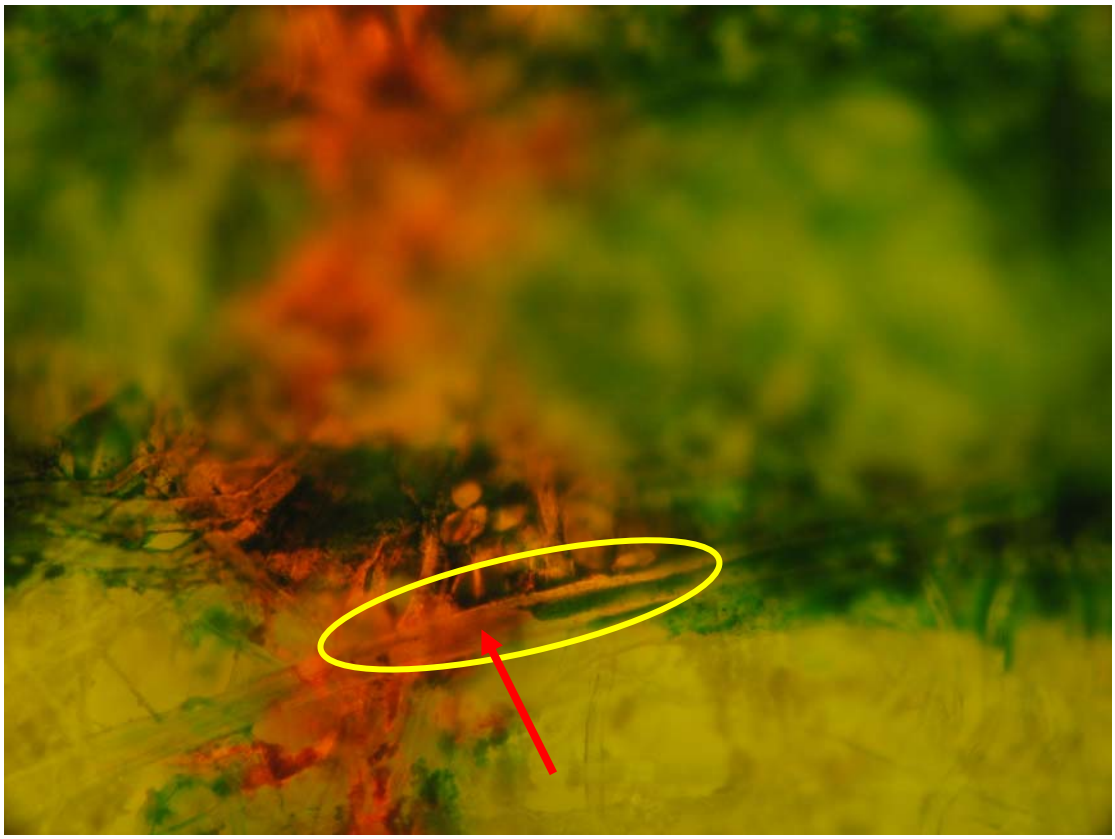

Fig. 2: pen ink above printer ink (10µm difference)

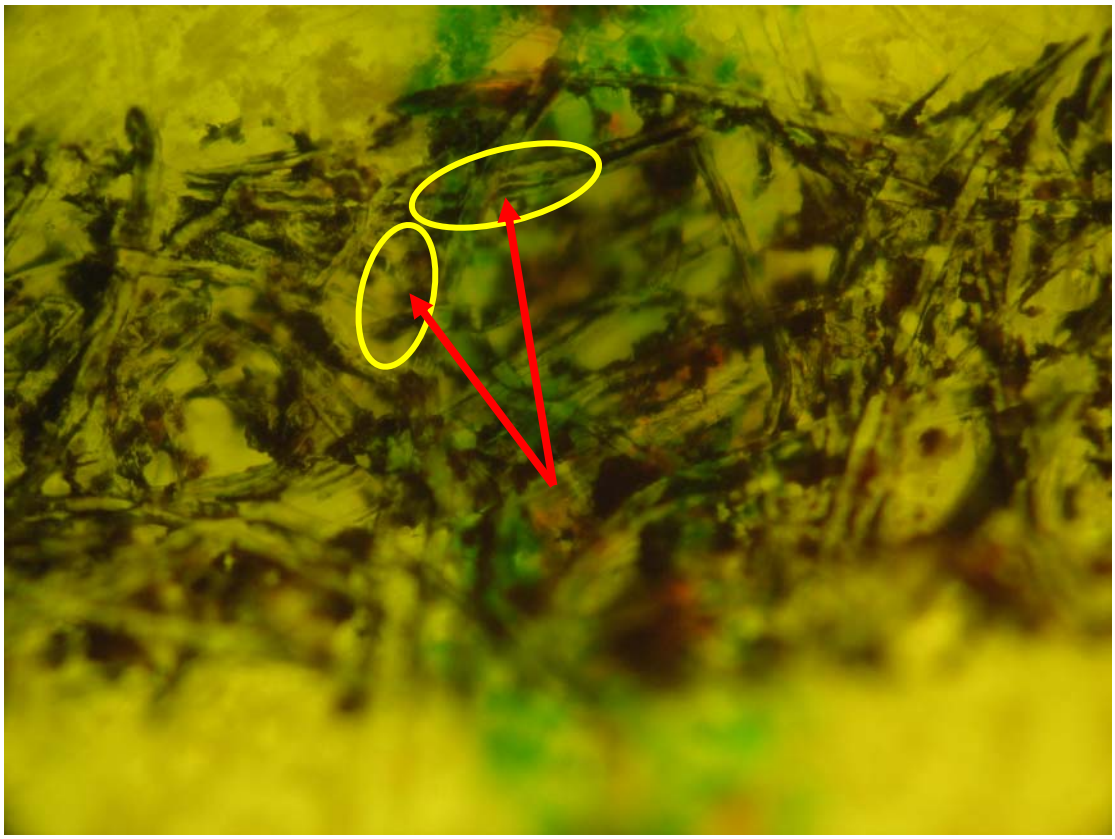

Fig.3: pen ink below printer ink (8µm difference)

This study shows that only two spots of ink deposited on one fiber are needed for determination of the sequence of crossing lines. The method used in this study is a non destructive method and thus, suitable for forensic examination.

CONCLUSIONS

Determination of the sequence of crossing lines using fluorescence microscopy is a very simple non destructive method joins to other more complicated and expensive methods that try to solve the challenging problem of crossing lines. This method is inexpensive and rapid. The major limitation of the method is the need of fluorescing inks. A comprehensive solution to the problem of crossing lines is a combination of all the methods available (SEM, AFM, FTIR, Fluorescence microscopy, and Laser profilometry).

REFERENCES

1. Gal, Sandor, Karoly, "Determining the sequence crossed lines by FT-IR-ATR microscopy", AF # 409E Bruker optics
2. Giuseppe Schirripa Spagnolo, "Potentiality of 3D laser profilometry to determine the sequence of homogenous crossing lines on questioned documents", Forensic science international 164 (2006) 102-109.
3. Kasas, Khanmy-Vital, Dielter, "Examination of line crossing by atomic force microscopy", Forensic science international 119 (2001) 290-298.
4. Waeschle, "Examination of line crossing by scanning electron microscopy", Journal Forensic science 24, 3 (1979) 569-578.

Back to Top