HARRICK SCIENTIFIC PRODUCTS

applications note

No. 50107

The Color Of Money: A Diamond ATR Study of the new Twenty Dollar Bill

Figure 1. The Video Meridian Diamond ATR Accessory.

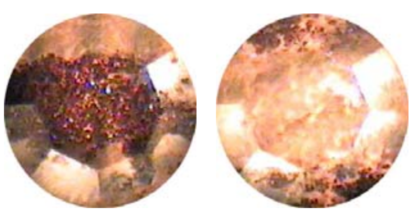

Figure 2. Photographs of the red (left) and gold (right) sections of the bill.

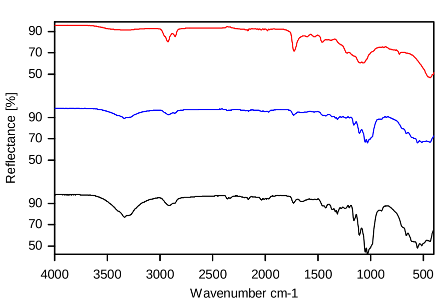

Figure 3. ATR spectra of the shiny "20" on the face side of the bill: red section (upper), gold section (middle) and an unprinted section (lower).

Introduction

The year 2003 presented big changes for the greenback - the United States Mint introduced a new, multicolored twenty-dollar bill. This new design is intended to make forgery more difficult and detection of illegal bills easier by incorporating a greater variety of colored inks and textual details.

Detection of inks and dyes on substrates, like the greenback, is vital for forensics investigations and for the textiles and printing industries. For forensics, matching inks on papers and cloth from crime scenes to those used by suspects is vital in the investigation process. For the textiles and printing industries, colors and coating uniformity must be reasonably consistent from one lot to the next.

This applications note explores the use of video-imaging micro-ATR (μATR) to distinguish differences in chemical composition of various portions of the new twenty-dollar bill.

Experimental

The sample twenty-dollar bill was obtained directly from a local bank, in an attempt to obtain one with as few surface contaminants as possible. The bill selected was crisp and lacked winkles or folds, indicating that it was recently placed in circulation.

The sample was examined using the Video Meridian, a single reflection μATR accessory using a type IIA diamond, installed in the sample compartment of a commercial FT-IR spectrometer. All spectra were collected with 32 scans at 8 cm^{-1} resolution using a DTGS detector. The sample was compressed against the 500μm diameter sampling area of the diamond ATR crystal using the same force and then referenced against the clean ATR crystal. The sample was positioned using the digital image displayed on the computer screen and the image was captured for each section of the bill examined.

Results and Discussion

Figures 2 and 3 show the spectra recorded from two different sections of the golden "20" on Jackson's side of the bill. Figure 2 shows that there are two visually different parts of the "20" – one which is red and the other golden. The golden area just fills the octagonal sampling area of the ATR crystal, indicating that it is approximately 500 μm wide. The red section to its left appears somewhat wider, since its edges are not apparent. The spectra from these two sections are shown in Figure 3, along with the spectrum of an

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unprinted section of the bill. All three spectra show a band at 1100 cm^{-1}. This band is primarily due to the underlying paper since the ink coating does not completely cover the paper. The red portion has a significantly stronger carbonyl band at 1730 cm^{-1}, in addition to stronger bands in the C-H region. The spectrum of the golden section is nearly identical to that of the underlying paper, with significantly less intense bands. This masking effect is typically seen with extremely thin metallic coatings (<<10Å). Hence it is likely that the golden color on the bill is, indeed, a very thin gold coating.

Figures 4 and 5 demonstrate the ability to distinguish different colors of green. The top two spectra show bands at 1000 cm^{-1}, probably due to the paper substrate. All three spectra are slightly different, indicating the possibility that three different kinds of green ink or dye were used. The spectrum of the serial number has bands around 1400 cm^{-1}, indicating that the ink may contain an aromatic component, while that of the shield has a band near 1170 cm^{-1}, indicating a C-O bond. The spectrum of the zero shows both components, so it may be different ink entirely or a mixture of the two.

In addition to inks and coatings of various kinds, the paper itself has discernible fibers in it. Figures 6 and 7 show two sections from the edge of the greenback. One section has a noticeable blue fiber in it, which is approximately 65µm in diameter. The other was more uniform and was examined for a reference. The bands at 1715 cm^{-1} and 1250 cm^{-1} appear in the spectrum of the fiber but not in the spectrum of paper. Subtraction of the paper background spectrum from the fiber spectrum results in a spectrum that is clearly identifiable as polyester.

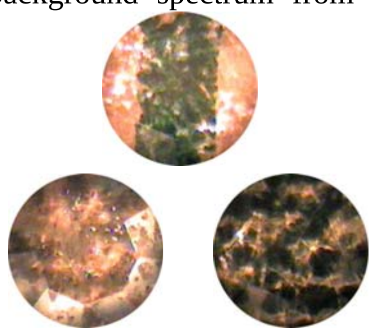

Figure 4. Photographs of the three green sections sampled: the serial number (top), the shield (lower left), and the zero (lower right).

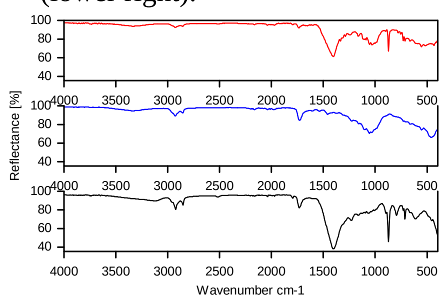

Figure 5. ATR spectra of green printing on the new twenty-dollar bill taken from the serial number near Jackson (top), the shield next to Jackson (middle), and the large zero on the lower left below the White House (bottom).

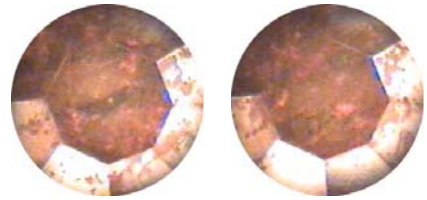

Figure 6. Photographs of the blue fiber (left) and substrate (right).

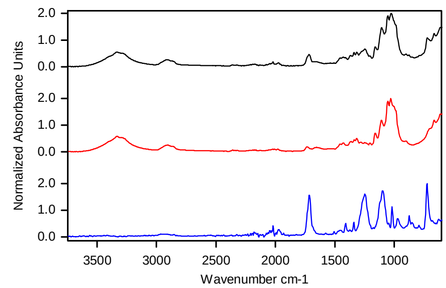

Figure 7. Normalized ATR Spectra of a blue fiber (top) on the greenback, an area near that blue fiber (middle), and the difference (bottom).

Summary

As shown above, µATR, combined with video imaging, is a powerful tool for examining differences in chemical composition of fine details on substrates. Such samples are routinely examined in the forensics and textiles forensics industries; and the Video Meridian provides the tool to obtain detailed information quickly and easily.

HARRICK SCIENTIFIC PRODUCTS
141 Tompkins Ave., 2nd floor • PO Box 277 • Pleasantville, NY 10570
www.harricksci.com • E-mail: info@harricksci.com
Phone (international): 914-747-7202 • Phone (in USA): 800-248-3847 • Fax: 914-747-7209