PART 1: BALLISTICS, TOOL MARKS, AND QUESTIONED DOCUMENTS / COUNTERFEITING / FORGERY

Forensic Applications

INVESTIGATIONS DONE EASY AND FAST

Leica DVM6 Digital Microscope

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More Efficient Forensic Analysis with Digital Microscopy

The examples reported here demonstrate how the Leica DVM6 digital microscope enables forensic scientists to gather and compare evidence from ballistics and tool marks or counterfeited money, credit cards, and documents, more efficiently.

Digital microscopes [1], optical microscopes without eyepieces which display the image directly on a monitor, have become very practical for a variety of applications in multiple fields [2-8]. Recently, dramatic improvements have made digital microscopy even more practical and powerful, allowing a more efficient workflow for forensics.

The DVM6 enables workflow to be more efficient due to specific features:
> Simple, rapid way to change magnification with the 16:1 zoom optics and fast one-handed objective swap;
> Intuitive software for microscope operation and analysis;
> Automated tracking and storing of important parameters due to full encoding of the microscope;
> Fast microscope head tilting and sample rotation; and
> Fully Integrated ring light, plus coaxial and other illuminations.

**Leica DVM6**

The Leica DVM6 has a 16:1 zoom and three objective lenses which cover a magnification range of 12x to 2,350x. The objectives, seen below, can be changed quickly and easily, as shown in this video online.

The microscope head of the DVM6 microscope can tilt eucentrically from -60° to +60° and the sample stage can rotate from -180° to +180°. Users can both tilt the head and rotate the stage with just one hand. In addition to the integrated LED (light-emitting diode) ring light and coaxial illumination, there is also the possibility to install a spotlight (Leica LED5000 SLI) and transmitted light (BLI) illumination. The motorized stage of the DVM6 allows extended depth of field (multi-focus) images along the vertical (Z) direction and stitching of images along the horizontal (XY) direction. Even the combination of XY and Z stitching is possible and allows larger fields of view with high Depth of Focus and 3D modelling. A bullet holder made especially for the DVM6 to perform forensics investigations is shown in this report on page 3.
Tilt of the microscope head over ±60° and rotation of the sample stage over ±180°.

Integrated LED ring light and coaxial illumination.

The Leica DVM6 with spotlight (LED5000 SLI) and transmitted light illumination (BLI) installed.

Examination of paper money using transmitted light or ring light/coaxial illumination of the Leica DVM6.
Firearms and Tool Marks

Ballistic Evidence

The entire cartridge can be imaged with the Leica DVM6 when using features like XY stitching and the Extended Depth of Field (EDOF), making it easy and fast to get a large overview, high quality image of the cartridge sample analyzed. Images from the Leica DVM6 of bullets after being fired from a firearm are shown below.

XY stitched image of a bullet fixed on the bullet holder shown above.

Details of striations on a bullet from the barrel.
Multi-focus image in 2D (left) and 3D (right) of a bullet nose.

Multi-focus image in 2D (left) and 3D (right) of a nickel plated cartridge case showing the firing pin mark on the primer.

Multi-focus image in 2D (left) and 3D (right) of a brass cartridge case showing the firing pin mark on the primer.
Counterfeiting/Forgery: Money, Credit Cards, Documents, and Identification

Analysis of money, credit cards, documents, and identification cards can be done quickly with the Leica DVM6 due to the 16:1 zoom range, versatile integrated illumination, and one-handed tilting. Images from the Leica DVM6 of paper money, a credit card, and an identification card are shown below.

Money

When analyzing money, forensics experts can change quickly from an overview to visualizing fine detail using the zoom optics of the Leica DVM6. Below are overview and zoom-in images showing fine details on paper money recorded with the Leica DVM6.

South African 50 Rand bill with more detail seen after zooming in (right).

US Dollar bill with more detail seen after zooming in (right).
**Credit Cards**

Forensics experts can easily see more detail when using the versatile integrated illumination of the Leica DVM6. The holographic image (pigeon) of a credit card was illuminated with the ring light of the Leica DVM6.

As the illumination cycled through each of the ring light LED segments, four images were recorded and captured in this YouTube video.

**Identification**

With one-hand tilting, users can focus on the displayed image and finding what is needed during the analysis and not on the sample stage or microscope head.

Images of a security hologram on a Swiss Identification card recorded with increasing tilt of the Leica DVM6 microscope head are shown in the table below and in the YouTube video to the right.
Documents: Analysis of crossing lines

Determining the sequence of crossing lines is one of the most challenging problems for forensic examination of documents. Currently, there is no standard method for this type of analysis. To distinguish which crossing line was made first on a document and which one second, the Leica DVM6 offers an easy and reliable solution for examination of intersecting markings on a document.

With multiple built-in lighting methods, such as ring light and coaxial illumination Leica DVM6 users you can determine clearly and quickly the order in which crossing lines were made on a document. The integrated illumination allows the sequence of lines over and under toner markings (printer), lines over and under stamp markings, and stamp markings over and under toner markings to be identified. For the full picture, the tilting function of the Leica DVM6 allows users to further view the crossing lines from various angles.

Leica DVM6 image of crossing lines. It is difficult to see which line was made first and which one second.

With the combination of integrated ring light and the coaxial illumination the order in which the crossing lines cross can be revealed.

Leica DVM6 image of a document showing different marks from a stamp, from toner, and from an ink pen.

The illumination clearly reveals that the stamp (blue) was done first, followed by the pen lines (violet), and then finally toner was printed on top of them.
Summary

Summary table showing which features of the Leica DVM6 are useful for certain forensic analyses [9]. An X means the feature is “useful” for the particular analysis and an (X) means it is “likely useful”.

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<th>Magnification</th>
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Conclusions

The results reported here show that forensic analysis of evidence from ballistics, paper money, credit cards, and identification cards can be obtained efficiently with the Leica DVM6 digital microscope.

The fast workflow is due to the Leica DVM6’s many practical features, such as a convenient way to change magnification rapidly over the full range, tilting, sample rotation, and versatile illumination. Faster workflow efficiency leads to fast data acquisition and analysis for forensics.
Additional Reading

1. J. DeRose, G. Schlaffer, What You Always Wanted to Know About Digital Microscopy, but Never Got Around to Asking, Science Lab

2. J. DeRose, G. Schlaffer, Digital Microscopy with Versatile Illumination and Various Contrast Methods for More Efficient Inspection and Quality Control: Example applications using the Leica DVM6 with integrated ring light or coaxial illumination system, Science Lab


4. J. DeRose, G. Schlaffer, Automotive Industry: Rapid and Precise Surface Inspection on Hard-to-Image Samples, Leica Microsystems Website


8. J. DeRose, G. Schlaffer, Leica DVM6 Digital Microscope: Leica DVM6 Digital Microscope: Encoded for Reproducible, Reliable, Efficient Inspection and Analysis of Automotive Parts, available from local Leica Microsystems sales representative or authorized dealer

9. Leica DVM6 Internet Product Page, Technical Specifications