# Forensic analyzer systems

*multi-purpose laboratory analyzer*

*portable analyzer with remote fiber-optic sensing*

*vehicle mounted system*

## A unique range of Raman spectroscopy systems designed for use by law enforcement agencies

- multipurpose Raman analyzer for laboratory use
- portable Raman analyzer for on-site/scene of crime use
- advanced UV Raman systems for specialist applications

**Applications**

- narcotic identification
- explosive identification
- fiber identification
- paints/pigments analysis
- gunshot residue analysis
- gemstone identification

**Advantages**

- non-destructive analysis
- analysis through transparent packages, including evidence bags
- remote optical fiber analysis (over 100 m)
- fast material identification with extensive software libraries
- no sample preparation needed
- samples as small as 1 µm can be studied

**Usage**

- forensic applications worldwide

systems for law enforcement agency use

RENISHAW®

# *Forensic analysis*

## The advantages of the technique...

- state-of-the-art Raman technology
- unique characterization of materials
- rapid analysis
- non-destructive - evidence is preserved
- no sample preparation required
- material inside most transparent packaging can be analyzed

## ...and of the analyzers

- easy-to-use automated systems
- rugged
- fast material identification using extensive software libraries
- traceability and data transfer between different instruments
- in-built automated calibration routines
- high spatial resolution (to 1 µm for laboratory analyzer)
- spectral libraries for material identification

## in the laboratory...

- easy sample loading - as simple as using an ordinary optical microscope
- video viewer for rapid positioning of the sample, with image capture facility
- automated sample stage for 2-D mapping of surfaces with focus-tracking for rough surfaces

## ...and in the field

Customization options:

- mobile operation (trucks etc.)
- extra rugged for in-field use
- stabilized mounts for fiber optic probes
- fiber probes with remote viewer for probe positioning
- battery operation developments

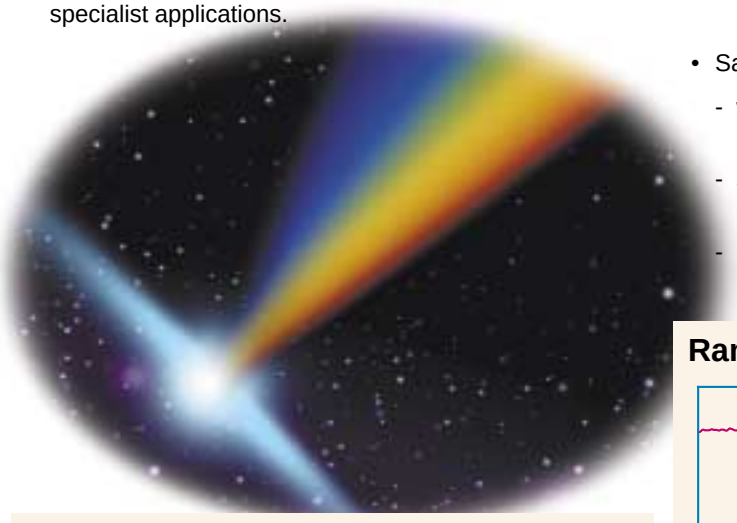
## Complementary techniques: Raman and IR

Raman scattering and infrared absorption are complementary techniques: both use light to probe the molecular structure of materials, and can identify the composition of unknown substances.

In infrared absorption, light is absorbed when its frequency matches that of one of the bonds in the molecule. This absorption occurs at relatively long wavelengths, in the infrared region of the electro-magnetic spectrum.

In the Raman case, the molecule scatters incident laser light, reducing its frequency as bonds are set vibrating. The reduction in frequency of the light corresponds to the vibration frequency of the bond.

The majority of lasers used for Raman spectroscopy have visible or near-visible emission frequencies, resulting in scattered light frequencies that are also visible or near-visible. Instruments using ultraviolet excitation are also available for specialist applications.



### Raman and IR

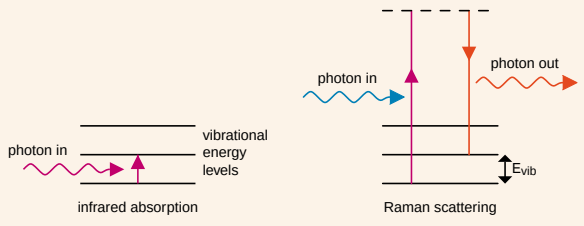


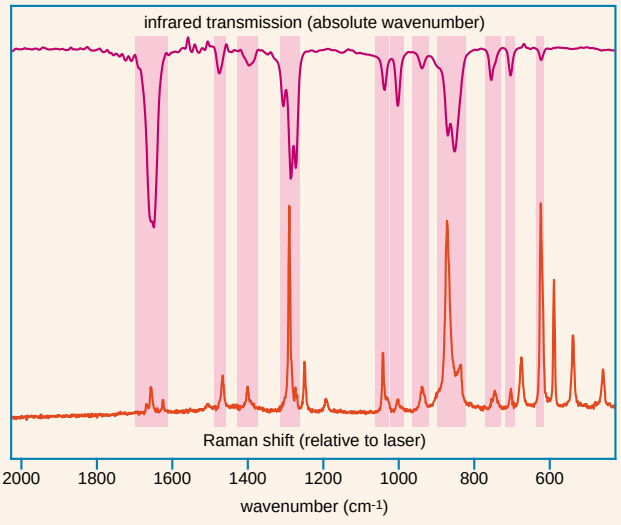

Diagram illustrating infrared absorption and Raman scattering.

## Differences between Raman and IR

Raman has advantages over infrared absorption

- It is non-destructive
  - samples require no preparation
  - technique is non-contacting
  - evidence is preserved
- High temperature studies can be performed easily
- Lower Raman shift coverage; 100 $cm^{-1}$ possible with standard optics. This allows a wider range of materials to be studied
- Microscopy:
  - smaller particles can be studied than IR (1 µm to 2 µm across, an order of magnitude better than IR)
  - confocal measurements are easy (high depth and lateral resolutions) allowing embedded particles to be analyzed
- Sampling is easier:
  - water is the ideal solvent, glass the ideal container/window material
  - samples within transparent plastic containers can be studied
  - a wide variety of sample shapes and sizes can be accommodated

### Raman and IR spectra




Raman and infrared spectra of PETN explosive, showing the correspondence between the two.

*Data courtesy of Prof. D.N. Batchelder, University of Leeds.*

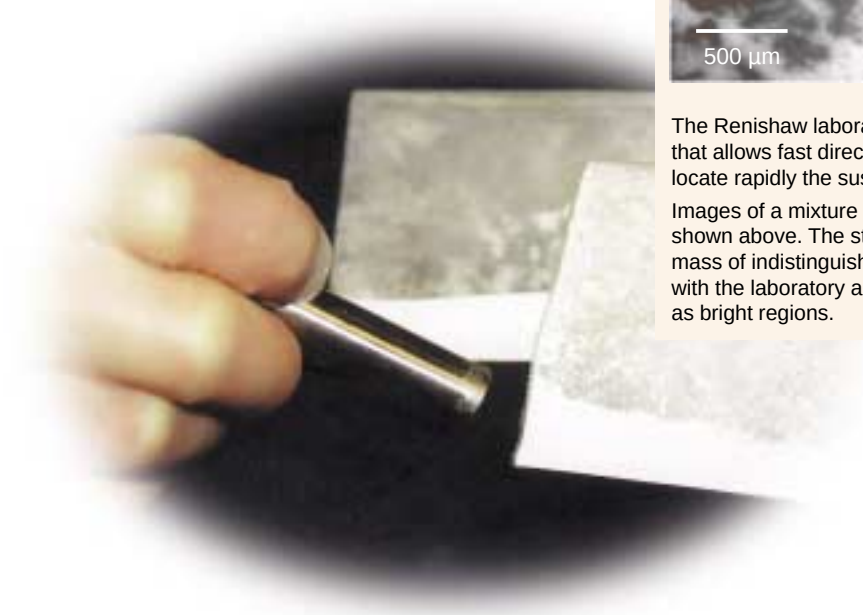
# Forensic analysis

## Narcotics/drugs

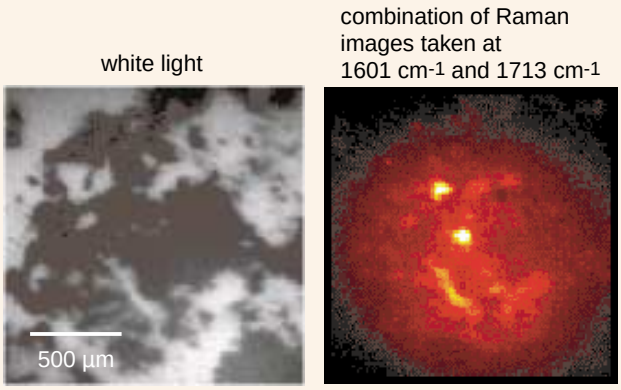
The Renishaw forensic analyzers are ideal for detecting and identifying all the common narcotics, including:

- cocaine, and cutting agents (sugar, chalk, etc.)
- amphetamines; characterization of manufacturer source

Narcotics can be identified even after they have been “cut” with other substances.



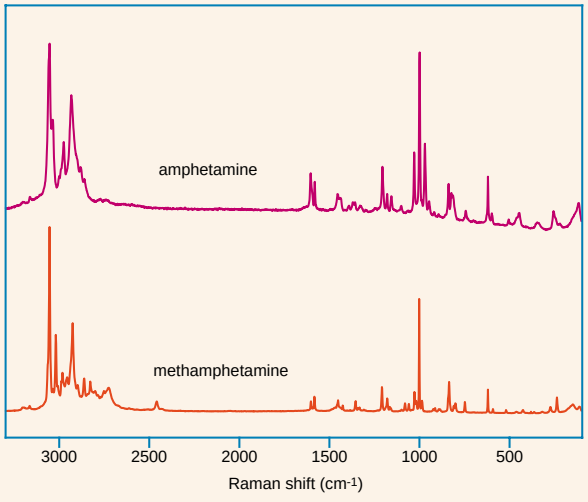
### Detection




The Renishaw laboratory analyzer has a unique filter system that allows fast direct 2D imaging. This facility can be used to locate rapidly the suspect material.

Images of a mixture of cocaine hydrochloride and sugar are shown above. The standard microscope image (left) shows a mass of indistinguishable material, whereas the image taken with the laboratory analyzer (right) reveals particles of cocaine as bright regions.

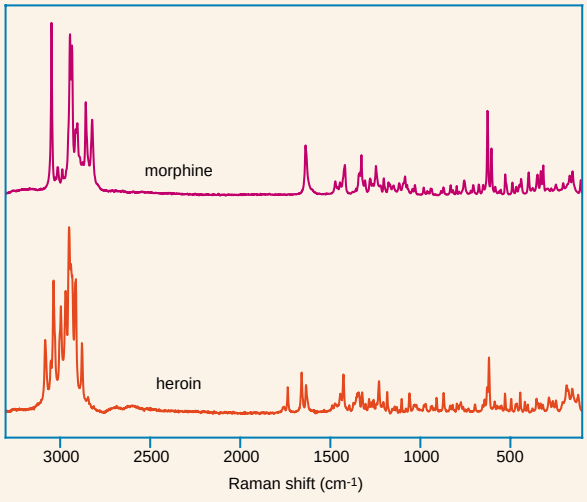
### Identification




Spectra of amphetamines.

*Data courtesy of Profs. Zhao JT and Zhang PX, Yunnan Polytechnic University, Kunming, PR China.*

### Identification



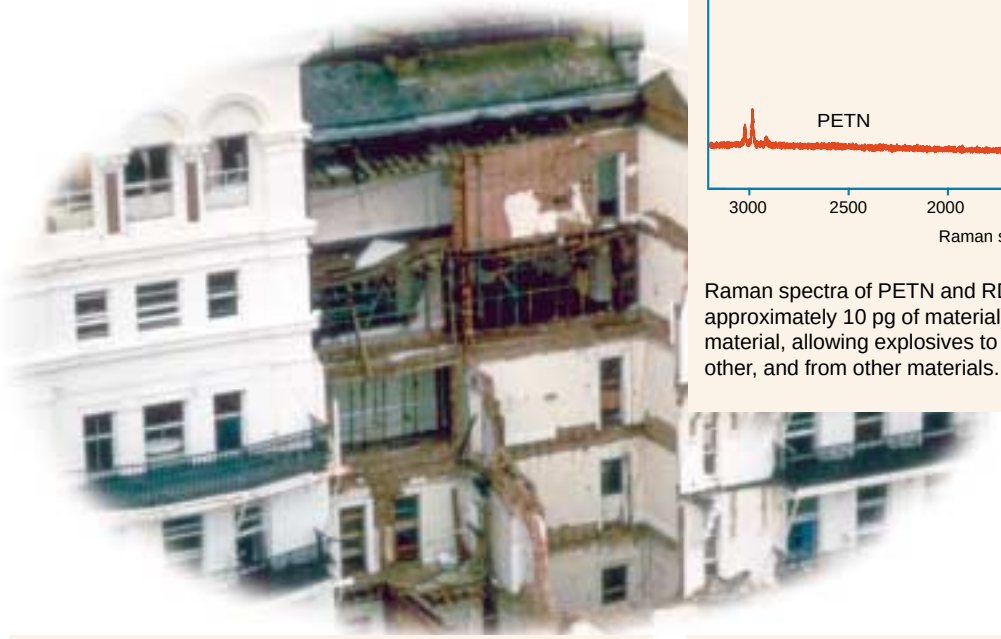

Spectra of morphine and heroin.

*Data courtesy of Profs. Zhao JT and Zhang PX, Yunnan Polytechnic University, Kunming, PR China.*

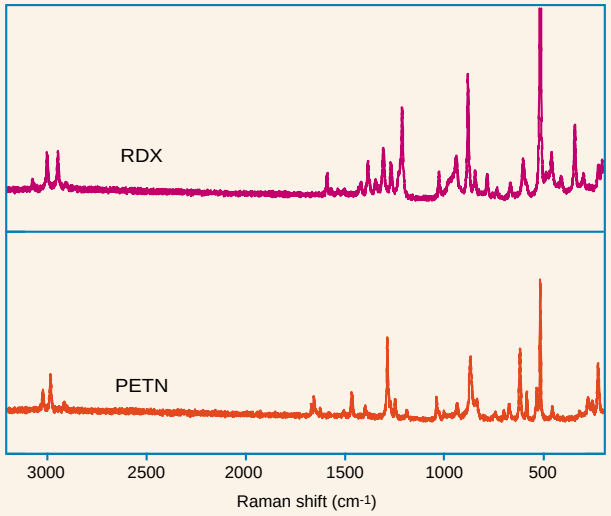
# Explosives

The Renishaw Raman forensic analyzers can analyze all of the common explosives and associated materials (TNT, Semtex, ammonium nitrate/sugar, etc.)

Traces of explosive can be detected non-destructively and identified on a wide range of materials, including fabrics, metals and paintwork, without the need for sample preparation.

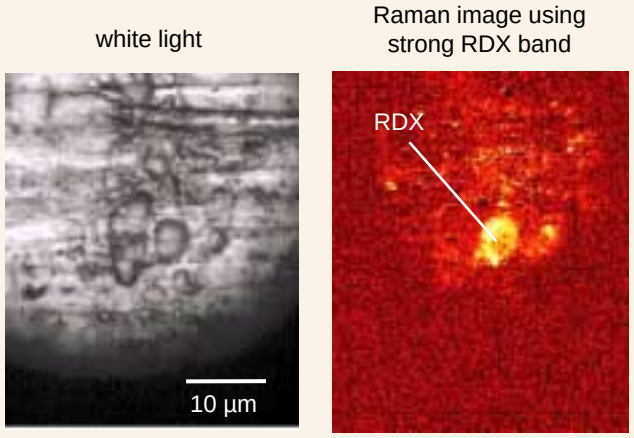


## Identification



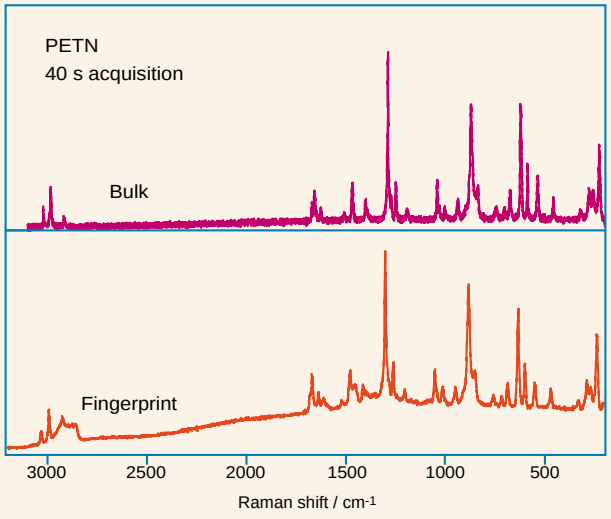

Raman spectra of PETN and RDX explosives (each from approximately 10 pg of material). The spectra are unique to the material, allowing explosives to be distinguished from each other, and from other materials.

## Detection




Images of a fingerprint on aluminum taken with a standard microscope (left), and with the laboratory analyzer (right). A particle of RDX explosive, a few micrometers across, is clearly revealed on the Raman image from the analyzer.

## Remote detection




Raman spectra of PETN explosive.

Top: bulk material spectrum taken with the laboratory analyzer. Bottom: traces of explosive in a fingerprint examined using a remote fiber optic probe (finger grease features are also present in the spectrum)

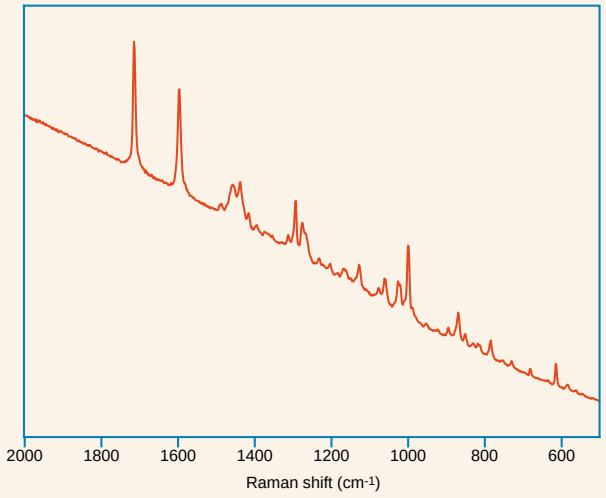
# *Forensic analysis*

## *In situ* studies through packaging

Renishaw's Raman systems can acquire spectra from samples contained within a wide range of transparent/translucent packaging materials, such as glass vials and plastic bags.

This allows materials (such as narcotics contained within evidence bags) to be identified without disturbance.

**Identification**



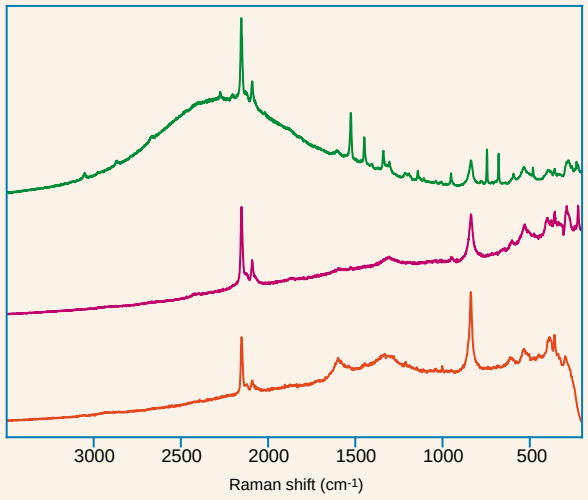

Spectrum of cocaine taken through a plastic (polyethylene) bag. The Raman bands of the cocaine appear on a luminescent background from the bag (633 nm excitation).

## Paints and pigments

Spectra taken from paint particles differ widely, depending on the paint type and manufacturer. A typical application of this capability is the linking of tiny paint particles to a vehicle involved in a road accident.

The high spatial resolution of the laboratory analyzer allows different layers of the paint fragment (corrosion inhibitor, undercoat, etc.) to be studied, giving even greater discrimination.

**Identification**



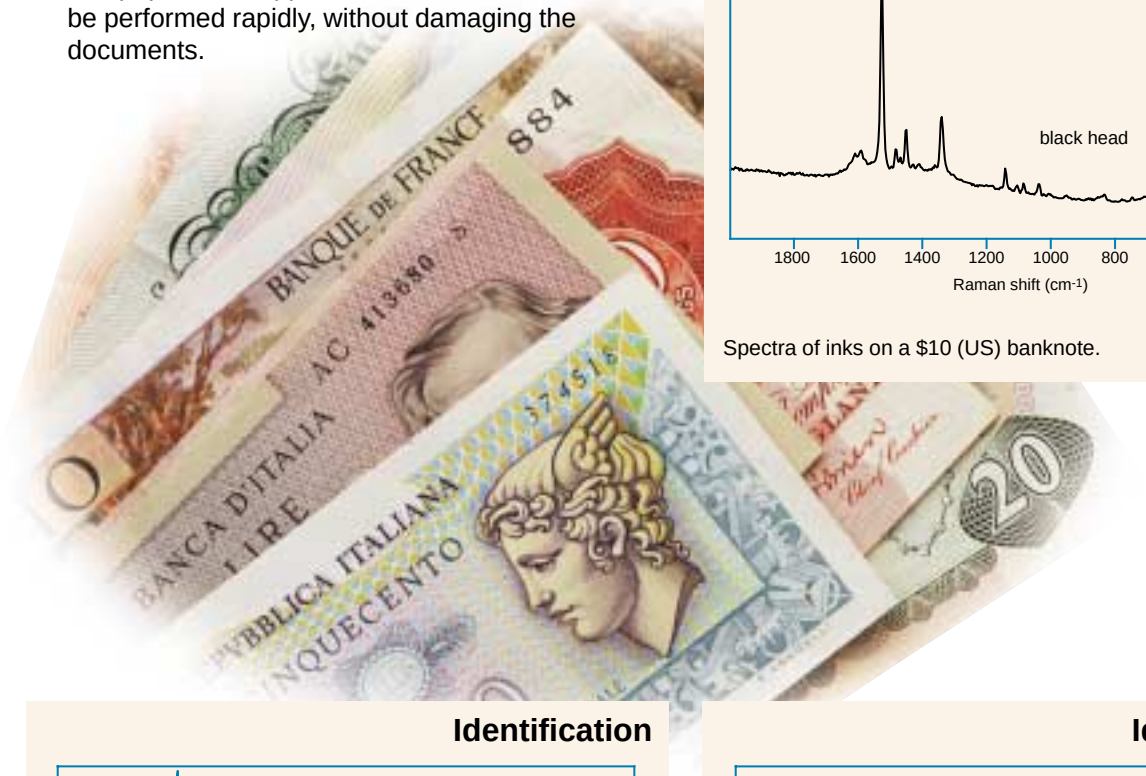

Typical paint spectra, in this case from three different green paints. They can easily be distinguished from each other.

*Data courtesy of Niu TL, Police Ministry, PR China.*

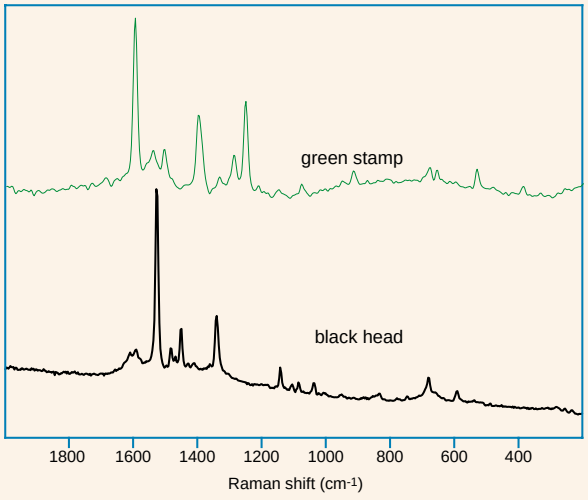
# Forgery of printed material (banknotes etc.)

The advent of inexpensive printing and publishing technology has enabled criminals to forge convincing documents with great ease.

The Renishaw forensic analyzers can be used to distinguish between pigments, paints, and papers that appear identical. This can all be performed rapidly, without damaging the documents.

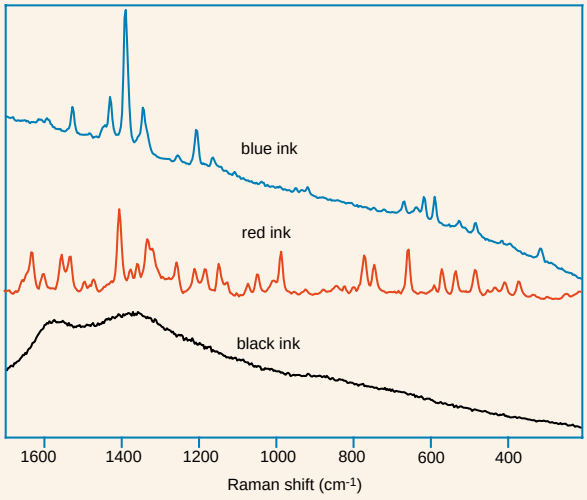



## Identification



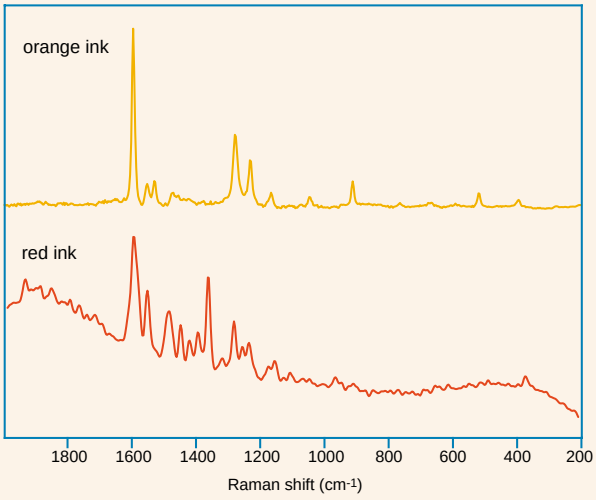

Spectra of inks on a $10 (US) banknote.

## Identification




Spectra of inks on a 100 Yuan (Chinese) banknote.

## Identification




Spectra of inks on a £10 (Sterling) banknote.

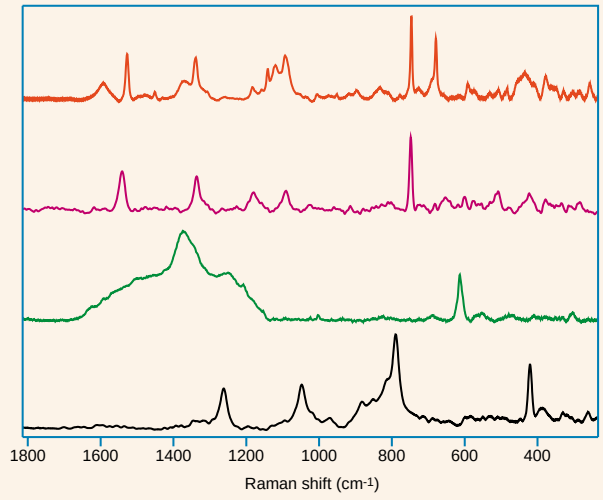
# *Forensic analysis*

## Handwriting forgery

Many inks appear identical when viewed with the naked eye, or with a conventional microscope, making it difficult to detect forged signatures and other such document adulteration.

However, the molecular compositions of inks vary markedly, allowing the Renishaw forensic analyzers to distinguish between them. The high spatial resolution of the Renishaw analyzers enables inks to be identified on paper and other materials.

**Identification**



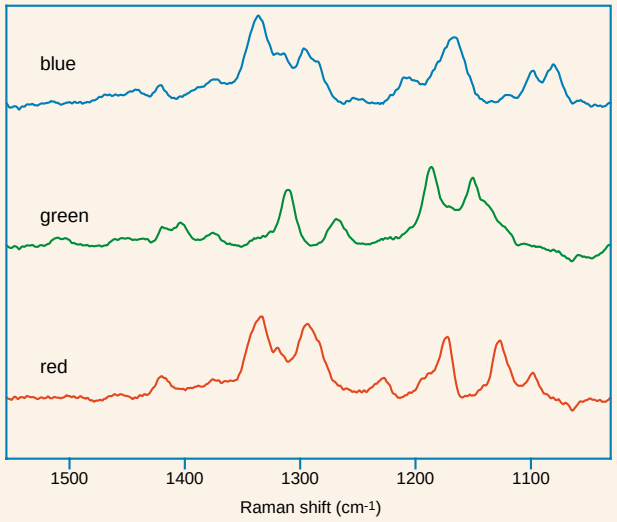

Spectra of a range of blue and black inks from ball-point pens.

*Data courtesy of Niu TL, Police Ministry, PR China.*

## Fiber identification

The high spatial resolution of the laboratory analyzer makes it ideally suited to identifying single fibers that have been transferred during crimes. The resulting spectra enable not only the fiber material but also the fiber pigments to be identified.

**Identification**




Spectra from a variety of fibers.

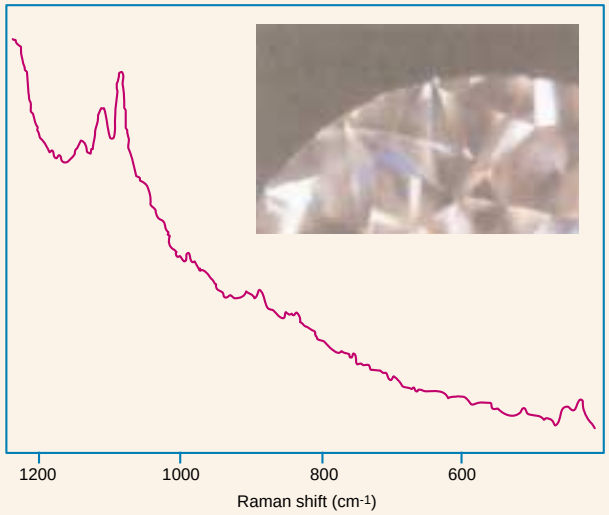
# Synthetic minerals and gems

The Renishaw forensic analyzers are ideal tools for identifying gemstones.

Renishaw's **inorganic database** of spectra enables the composition of suspect gemstones to be determined rapidly.

The high resolution of the laboratory analyzer's microscope also allows users to detect and identify microscopic flaws in gemstones, and the resins and fillers used to hide them. The same technique can be used to study inclusions in gems to determine their source.

## Detection of gem flaws



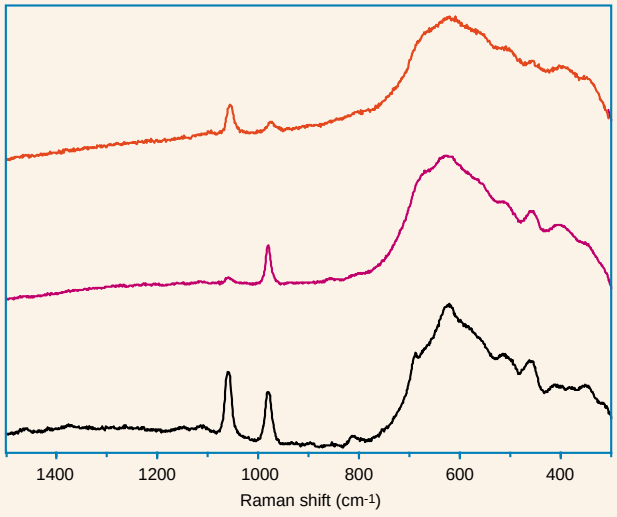

Spectrum taken from a faint feature in a diamond (inset image) reveals that a resin has been used to fill a crack in an attempt to hide it.

*Data courtesy of J Yuan International Inc.,Taiwan.*

# Gunshot residues

Gunshot residues consist of materials such as carbonates, nitrates, and oxides, (originating from the explosive), along with compounds associated with the projectile and gun barrel. The residue particles typically range in size from 1 µm to over 100 µm across, and can be examined easily with the Renishaw laboratory analyzer.

## Identification




Spectra of three gunshot residue particles, exhibiting features associated with barium oxide (BaO) and barium carbonate ($BaCO_3$).

*Data courtesy of Prof. J. Yarwood, Sheffield Hallam University.*

## Spectral libraries

The complexity of a molecule's Raman spectrum is directly related to the complexity of the molecule. Many molecules of interest to forensic scientists contain large numbers of atoms, and therefore have relatively complex spectra.

This richness allows materials to be distinguished by their spectra, but sometimes makes identification difficult. Spectral libraries are therefore a valuable tool, especially as they allow technicians (rather than Raman experts) to perform routine analyses.

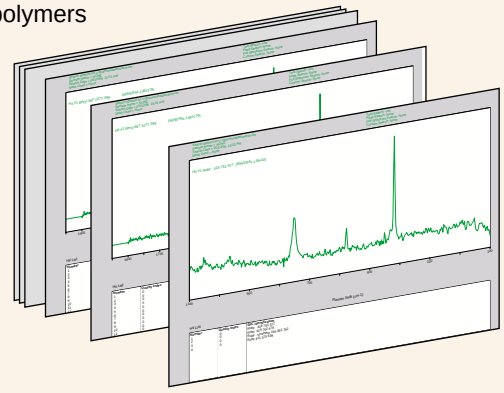

Renishaw's spectral libraries are easy to use:

- acquire the spectrum and start the library search
- the results are ranked in order of quality of match, with the best first
- both the unidentified spectrum and the match are displayed on the computer
- the user can display other possible matches to confirm the computer's selection
- the match can be subtracted from the unknown to reveal other, weaker, constituent spectra
- the spectra and match statistics can be printed for later analysis

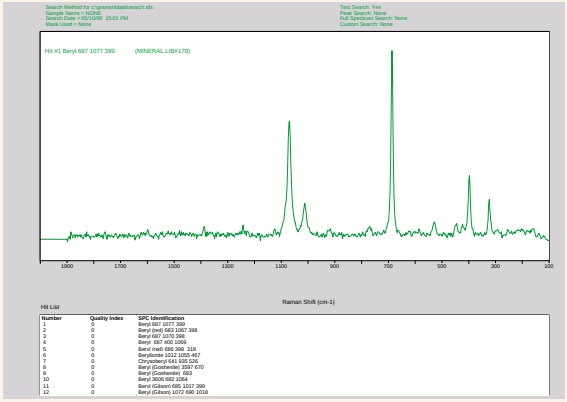
### Available libraries

Renishaw has produced a variety of spectral libraries, each containing a large number of spectra. Those of particular relevance to forensic applications are:

- explosives
- narcotics
- inorganics (minerals, gems, oxides)
- polymers



### Identification of gems




Spectrum from a supposed diamond is identified in seconds by the database as being that from a zircon.

The Renishaw inorganics database contains spectra from over 800 minerals, gemstones, and oxides.

## The Renishaw approach

Renishaw has long been world-renowned for its high precision measurement systems for quality control, research, and in-line process monitoring.

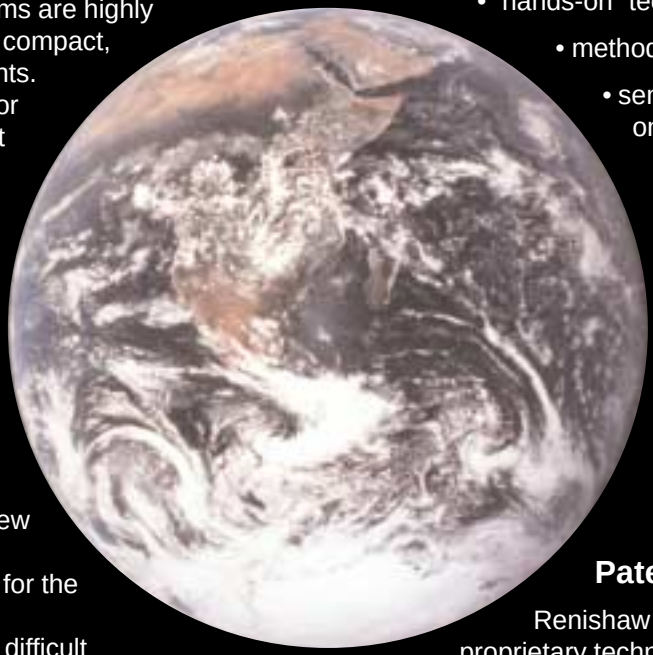
Renishaw was the first company to offer the new generation of Raman spectrometers, incorporating novel optical designs and recent advances in detector and filter technology. Renishaw's Raman systems are highly efficient, high throughput, compact, and easy to use instruments. They are the first choice for the Raman spectroscopist and analytical chemist alike.

These systems are causing a resurgence of interest in Raman spectroscopy, and are being applied routinely to both traditional and new application areas.

Renishaw continues to develop instruments for new applications, such as the ultraviolet Raman system for the analysis of **soils**, **contaminants**, and other difficult samples; please contact us for further details of our new systems.

Renishaw's Raman systems are currently in use with several law enforcement agencies around the world.

Renishaw is an ISO 9001 certified manufacturing company. Renishaw has been presented with a wide range of awards for technological and export achievement, both national and international.



## Global support & service

Renishaw recognises the importance of training, after sales service, and applications support, and is very proud of its world-wide servicing and product support network. Our team of Raman specialists and engineers offer rapid and comprehensive support:

- sample analysis
- "hands-on" technical training
- method development
- seminars and lectures, both on- and off-site

## Patents

Renishaw uses a variety of proprietary techniques to achieve the high instrument performance described in this brochure. These techniques are covered by a range of patents and patent applications:

CN 1162993

EP 0404901
EP 0542962
EP 0543578
EP 0638788
EP 0740133
EP 0776472

JP 2,733,491
JP 2,834,954
JP 504,650/1998
JP 119,865/1997

US 5,194,912
US 5,442,438
US 5,689,333
US 5,510,894
US 5,818,047

RU 97104125/4183

WO 92/22793

ZA 92/04145
ZA 92/08761


NRTL /C

CE

# Global solutions from Renishaw

Renishaw is an established world leader in metrology, providing high performance, cost-effective solutions for measurement and increased productivity. A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Renishaw designs, develops and manufactures products which conform to ISO 9001 standards.

Renishaw provides innovative solutions with the following products:

- Probe systems for inspection on CMMs (co-ordinate measuring machines).
- Systems for job set-up, tool setting and inspection on machine tools.
- Scanning and digitising systems.
- Laser and automated ballbar systems for performance measurement and calibration of machines.
- Encoder systems for high accuracy position feedback.
- Spectroscopy systems for non-destructive material analysis in laboratory and process environments.

Authorised distributor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