Forensic Car Paint Chip Analysis by QCL and FT-IR

Application Note MIC420

About Car Paints, Forensics, and IR Microscopy

In forensic analysis of evidence, IR microscopy has become indispensable. Fibers, particles and residues are chemically identified here in order to clearly assign an object or person to the crime scene, e.g. in hit-and-run car accidents.

Today, a car paint is a true high-tech product. It consists of many different layers with very specific tasks to give the vehicle a unique appearance. That is why a car paint is almost as characteristic for manufacturer and brand as a fingerprint. IR microscopy can therefore assign vehicles to an accident by analyzing microscopic paint chips.

Of course, precision and reliability are of paramount importance. However, the use of IR Laser Imaging in combination with FT-IR microscopy can not only improve the quality of the analysis, but also speed it up considerably.

The Difference Between IR Laser Imaging and FT-IR

While both provide characteristic IR information, IR Laser Imaging with quantum cascade lasers (QCL) has a much higher power density compared a thermal IR source that is typically used in FT-IR spectroscopy.

This results in an increased sensitivity allowing much higher imaging speeds. Currently, QCLs only provide analysis within a limited spectral range (1800 - 950 cm^{-1}) and a combination with FT-IR is key to ensure the analytical confidence needed.

Best Practice When Combining FT-IR and QCL:

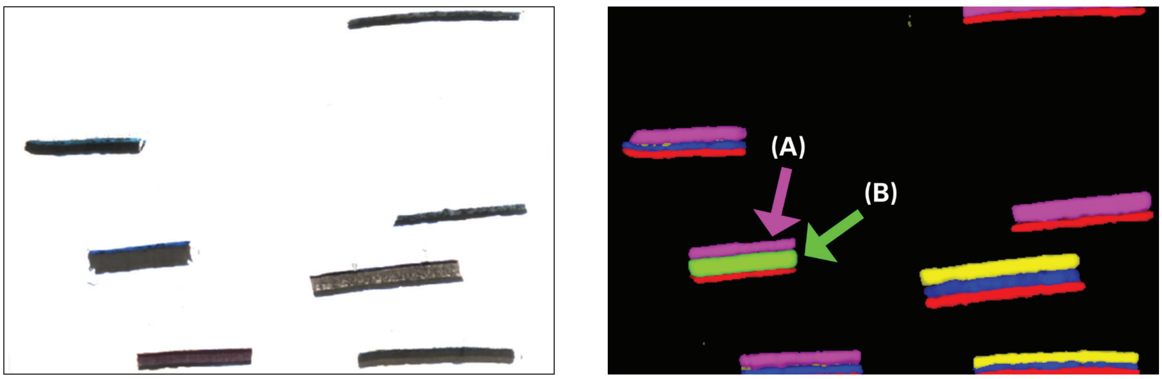
IR Laser Imaging focuses on the MIR fingerprint region (1800-950 cm^{-1}). FT-IR microscopy and IR Laser Imaging both can be used in transmission, reflection and ATR:
In a **spectral sweep** scan the range is freely selected and spectra are generated by a continuous sweep of the laser allowing for ultra-fast imaging. The resulting spectra are equal to FT-IR, as demonstrated in this application note.
IR Live Imaging permits the real-time view of a chemical image at video frame rates at a given wavenumber.
FT-IR microscopy can access a **broad spectral range** (450 – 6000 cm^{-1}) facilitating the identification of unknown substances and providing advanced reliability.
In conclusion, the **combination of QCL** with FT-IR allows the user to quickly locate regions of interest, measure them, and perform an unambiguous identification.

Application Example: Microtome Cut of Car Paints

Usually, car paint chips from a crime scene are collected, embedded in polymer resin and prepared with a microtome cut. It is also common practice to combine multiple chips into one microtome cut to boost efficiency. The IR measurement is then performed in transmission, yielding high spectral quality and speed while being completely non-invasive to preserve the evidence in its original form. In Figure 1, a visual image of a microtome cut containing multiple varnish samples embedded in epoxy is shown. When compared with the IR laser image below it becomes clear that not all layers are visible and only the prominent dark layers stand out.

The QCL image was collected across the full microtome cut area of 2.3 x 2.3 mm^2 over the complete fingerprint range 950 – 1800 cm^{-1} in less than 8 minutes with a pixel resolution of 5 µm resulting in a detailed and contrast-rich chemical image. It allows clear identification of all layers, making ROI selection much easier. To be honest, the visual image is hardly even necessary.

Figure 1: Visual reference image (top) and IR laser image (bottom). The increase in contrast makes it very easy to assess layers in paint chips. Afterwards, FT-IR measurements across the full spectral range were used to unambiguously identify the car paint chips. Same colors indicate the same layer materials.

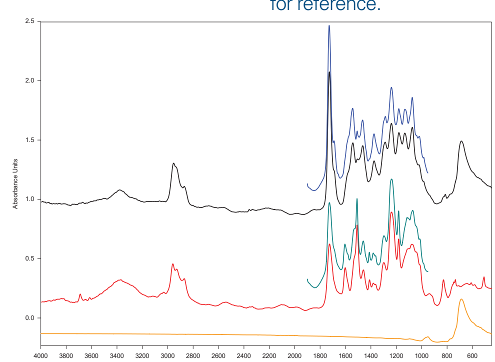


The Game-Changer: Combining QCL and FT-IR

While IR laser imaging delivers chemical images of amazing quality in very little time, it can not provide the full MIR information that is sometimes necessary to reliably identify an unknown sample. In particular inorganic pigments and filler materials often show their main spectral characteristics only in the region below 1000 cm^{-1}.

With the HYPERION II, Bruker removes this limitation and provides the option to have IR laser imaging and µ-FT-IR in one system. Using a broadband MCT microscopic IR-analysis down to 450 cm^{-1} can be performed, and often is applied in forensic sciences. The workflow is fully integrated and you can switch between the measurement modes with a single click and utilize both in parallel.

Figure 2: QCL and FT-IR spectra collected at position (A) and (B) on two different layers of a paint chip (see fig. 1). QCL and FT-IR spectra match perfectly. However, only a broad band MCT measurement reveals the inorganic flame retardant antimony(III) oxide which is characteristic for (A). Sb_2O_3 spectrum given for reference.



The Result: Increase Efficiency and Reliability

Figure 2 shows the full FT-IR spectra acquired immediately after IR laser image creation compared to the IR laser spectra. As you can see, the MIR region is in full accordance and total analysis time came down to less than 15 minutes.

The HYPERION II FT-IR QCL microscope combines state-of-the-art IR laser imaging with proven, reliable FT-IR technology into one easy workflow. Take advantage of both benefits and be more efficient.

Bruker Optics GmbH & Co. KG
info.bopt.de@bruker.com