Application Note AN MIC419

High-throughput Screening of Surface Contaminations by Infrared Laser Imaging (QCL)

About FT-IR and QA/QC of Precision Mechanics:

The quality requirements for precision mechanics are enormous. They are often part of complex assemblies, that require a large number of very special components. If one of these components carries a critical impurity, the entire assembly is in danger.

Here, FT-IR microscopy is a proven method to locate and identify unknown substances and contaminants based on their molecular vibration. This kind of analysis provides reliable, unambiguous indications of where a contamination is coming from and how to troubleshoot processes.

Finding Regions of Interest (ROI) Faster:

A common problem are transparent impurities (e.g. oil), that make finding the region of interest tedious. But still, manufacturers strive for 100% quality control, especially for valuable products or key mechanical parts.

Although FT-IR imaging is the obvious choice to make this feasible, achieving adequate sample throughput has not been easy using focal-plane array detectors. With the introduction of IR lasers, however, it is finally possible to judge samples by chemical properties in very little time.

This new technology allows the analysis of macroscopic surfaces (tens of cm^2) with micrometer resolution in just a few minutes, opening the way for new applications.

Keywords	Instrumentation and Software
FT-IR microscopy	HYPERION II IR Microscope
QCL imaging	Infrared Laser Imaging Module (ILIM)
Infrared Laser Imaging	OPUS Software
QCL FT-IR Combination	OPUS Search

Best Practice When Combining FT-IR and QCL:

IR Laser Imaging covers the mid infrared fingerprint region (1800-950 cm^{-1}). FT-IR microscopy and IR Laser Imaging both can be used in transmission, reflection and ATR.

Imaging at **discrete wavenumbers** focuses on specific wavenumbers instead of full spectra and allows to speed up the aquisition process significantly.

In a **spectral sweep scan** a spectral range is selected and spectra are generated by a continuous sweep of the laser. The resulting spectra are equal to FT-IR.[1]

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.

Using IR Laser Imaging to Find ROIs:

To demonstrate this approach, we examined a complete pocket watch, representative of the precision mechanics industry. Metal itself has no IR signature, so the surface of such a component acts like a mirror and allows IR light to reflect off the metal. However, if there is a small impurity present, it will absorb the IR light which we can detect by changes in the reflected light.

In this particular case (Figure 1), the watch was to be tested for residues of silicone oil. Accordingly, the Si-CH_2 band at 1250 cm^{-1} was selected for the IR laser analysis. The entire sample (30 x 30 mm) was scanned with 5 µm pixel resolution at this discrete wavelength in less than 3.5 minutes.

While the visual image shows no sign of contamination, the IR image reveals a significant difference. The outline of a stain is clearly visible in the IR image and contained to a small area of the watch (Figure 1, A).

Increasing Analytical Confidence by FT-IR:

Now that we know where the contamination is located, we switch to FT-IR microscopy with a simple mouse click. The mode change happens immediately and we can place FT-IR measurement points on the sample right after.

With the full MIR spectra we are able to perfrom a spectral reference library search to determine the nature of the residue. Figure 2 shows the identification result.In total, the analysis took less than 5 minutes and yielded an accurate and robust result.

This suggests two main use cases: First, one already has a catalog of common contaminants, uses IR Laser Imaging at discrete wavelengths to search for them, and verifies the result using FT-IR. Second, one spots an unknown impurity, identifies it with FT-IR, and then screens other samples for the same contamination using IR Laser Imaging.

FT-IR and IR Laser Imaging: Stronger Together

Many laboratories do not want to miss the well-proven performance of FT-IR - especially for unknown substances. Here, the HYPERION II combines modern, IR Laser Imaging with the comprehensive chemical info of full FT-IR spectra.

The HYPERION II software was designed to give an easy and lightweight user experience when changing IR modes. At a „click" you switch back and forth between techniques and analyze your samples at highest efficiency.

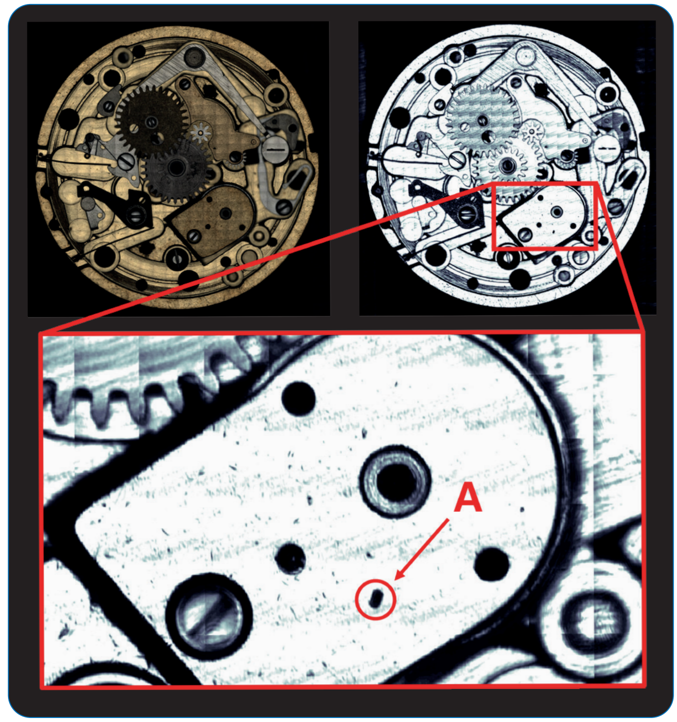

Figure 1: The visual image on the top left shows no indication of contamination or any presence of residue. The IR image at 1250 cm^{-1} (top right) shows a small contamination. Size and extent of the contamination become clear in the close-up. The watch's entire movement (900 mm^2) was analyzed in less than 5 minutes.

Compound information	
Compound Name	POLY(METHYLHYDROSILOXANE)
Molecular Formula	C7H22O2Si3
Molecular Weight	222.51
CAS Registry Number	63148-57-2
Sample Preparation	ATR single bounce
Reference	ET762/ NIC13927
Copyright	(c) 2014 Nicodom
Entry No.	4754
Library name	ATR-LIB-COMPLETE-2-472-2.S01
Library description	ATR-FTIR-Library COMPLETE, Vol. 2
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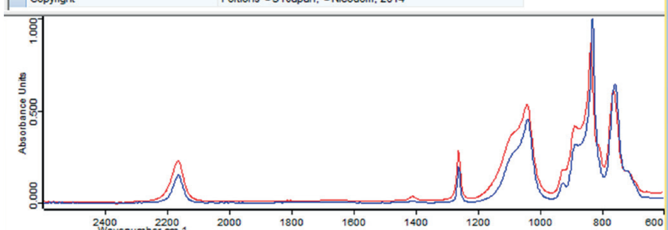

Figure 2: Spectral reference library search result using the FT-IR spectrum collected directly at the contamination. Spectrum was collected from 4000 - 600 cm^{-1}.

References

[1] Application Note MIC420: QCL in forensic analysis, Bruker Optics, 2021.

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