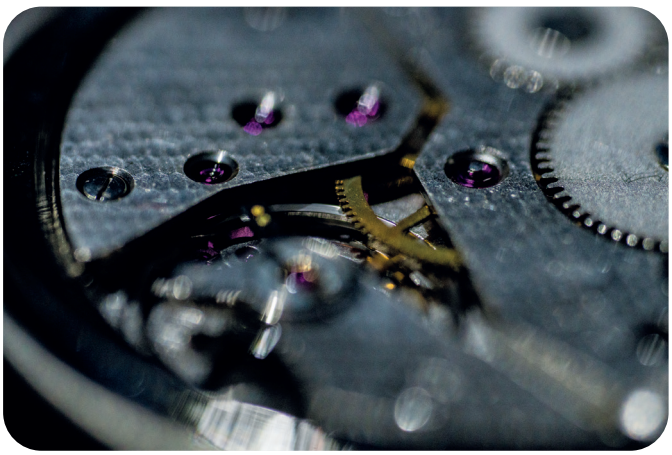

Application Note R537

Raman-Troubleshooting and Failure Analysis of precision mechanics

Small Components, Smaller Defects

There are many examples of tiny mechanical components in everyday items like electrical motors, cameras, and clocks. These parts significantly contribute to the funcionality of the whole device, but are prone to failure due to their delicacy.

In case of their failure, disassembly is not only costly but takes up a lot of time, making troubleshooting inefficient and tedious. Especially in complex assemblies, other parts might be damaged or contaminants may find their way into a formerly sealed housing while dismantling the sample.

Another difficulty may be the microscopic nature of the encountered defects. Uneven coatings and minuscule smears can have dramatic effects, and a chemical analysis may prove challenging or may seem impossible at first.

Figure 1:
Clock without cover glass under the 20x objective on the SENTERRA II sample stage. Cover glass was removed to improve visual inspection.

Keywords	Instrumentation and Software
Raman Microscopy	SENTERRA II
Mechanical Parts	Confocal Raman Microscope
Troubleshooting	OPUS/SEARCH
Electronics	OPUS/3D
Clocks and Watches	

How you can benefit from Raman Microscopy

The main benefit of Raman microscopy is the combination of a non-destructive, contactless chemical analysis with a brilliant visual performance and the possibility to measure behind optically transparent materials.

The SENTERRA II Raman Microscope features:

- Continuous and automatic calibration
- Intuitive and lightweight user experience
- Resolving power to even analyze nano defects
- Exceptional wavenumber stability and precision
- Visual data of a research grade optical microscope
- Chemical analysis of inorganic and organic materials
- True confocal measurements to analyze behind glass
- Multiple laser excitations to adjust to certain materials

Pocketwatch Troubleshooting

Most troubleshooting is done to assess possible errors within production processes or with raw materials. In the present case, a defective pocket watch was examined to determine the reason of failure.

Besides removing the cover glass to improve visual inspection no further parts were disassembled. The faulty cogwheel was quickly identified, since its teeth showed significant signs of unusual wear and tear (Figure 2).

Visual data revealed dark spots located on the cogwheel teeth and the wheel itself. Measurement spots were quickly selected and the analysis performed with a 532 nm laser.

The Value of Chemical Identification

Although the visual data gave first hints on the defects nature, yet only a chemical analysis by Raman would yield the whole picture.The dark residue on the cogwheel and teeth edges showed distinct signals of aliphatic hydrocarbons, most likely a lubricant or anti-corrosive sealant (Figure 3).

The residue's Raman spectra also revealed bands typical for inorganic material (below 1200 cm^{-1}). Upon closer inspection and after a successful reference library comparison, the unknown signals were identified as albite (Figure 4). This common silicate can be found around the world and has a Mohs hardness of 6–6.5.

The lubricant was suspected to becontaminated by small particles of albite. The then occuring degradation led to the failure of delicate machinery. During the review of the respective lubricant batch, the suspicion was conclusively confirmed and the defective batch disposed of quickly.

Summary

Identification of small, unknown contaminants and pollutants is readly feasible by Raman microscopy. The present analysis was done by removing the cover glass on the back of the watch, but is also possible through glass or otherwise optically transparent material.

The SENTERRA II features a lightweight user experience, making Raman microscopy a straightforward technique that yields immediate results.

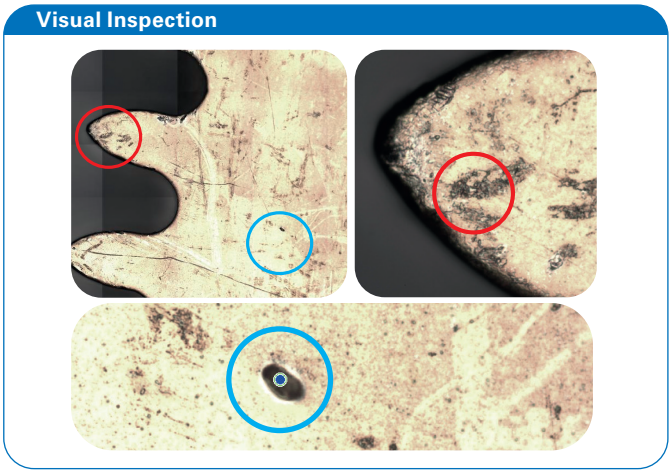

Figure 2: Visual inspection of faulty cogwheel and teeth. The dark residues were selected and analyzed with Raman microscopy.

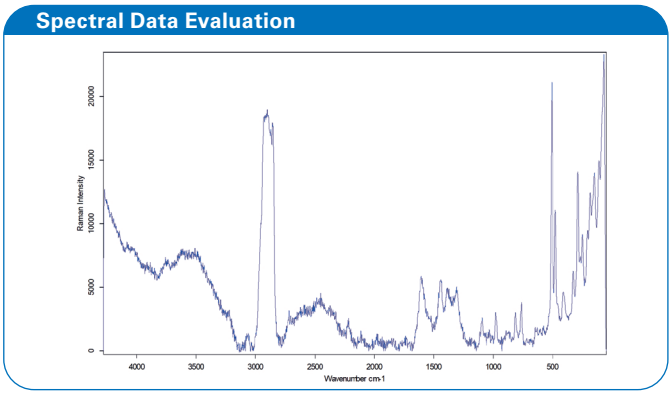

Figure 3: Spectrum of the residue on the metallic cogwheel. The C-H bands around 2900 cm^{-1} indicategrease or oil, most likely a lubricant.

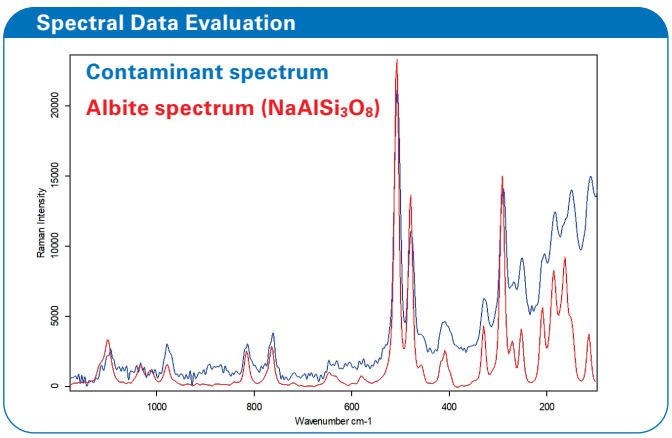

Figure 4: Contamination spectrum in the range of 1200 to 100 cm^{-1} (blue). The lubricant apparently contains albite (red), a silicate mineral.

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