



Micro Raman Spectroscopy for Characterizing Molecular Contamination on Space Flight Hardware

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Gugu Rutherford, Ph.D.
NASA Langley Research Center
gugu.n.rutherford@nasa.gov

Erin Acheson
College of Engineering, University of Maine, Orono
erin.acheson@maine.edu



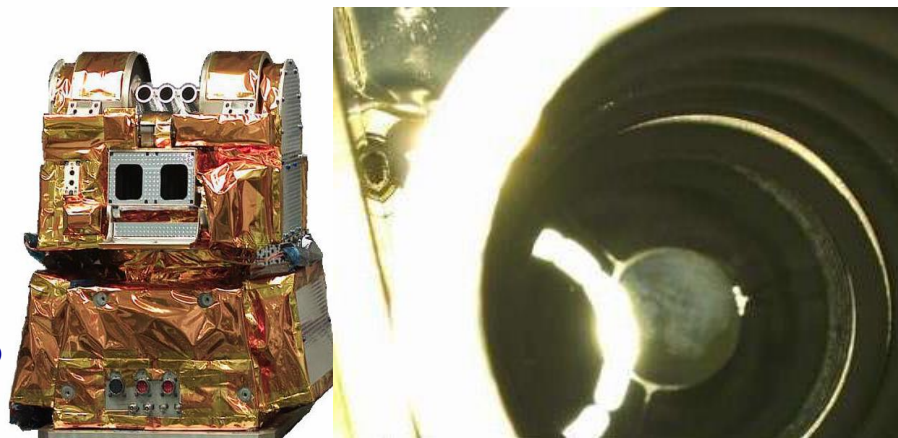


- **Introduction: Raman Spectroscopy for Detection of Contamination on Spacecraft**
- **Lessons Learned: Raman Detection of Contamination**
- **Proof of Concept Study: Micro Raman Spectroscopy for Detection of Contamination on Spacecraft**
- **Conclusion and Path Forward**

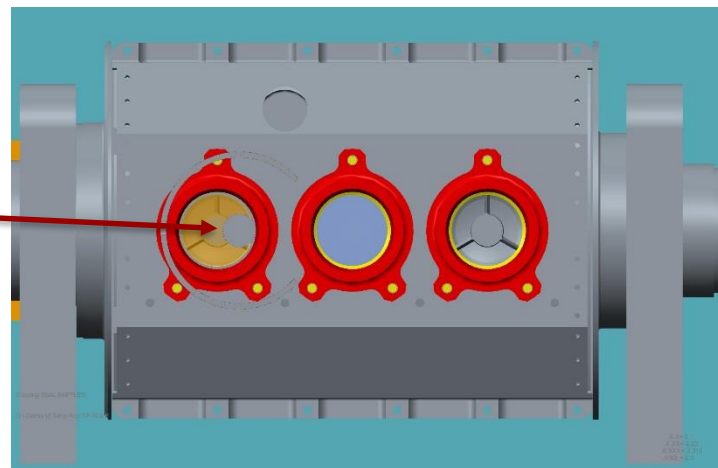
➤ Detection of Contamination on Spacecraft

<https://fpd.larc.nasa.gov/ceres-fm6-iraman-photos.html>

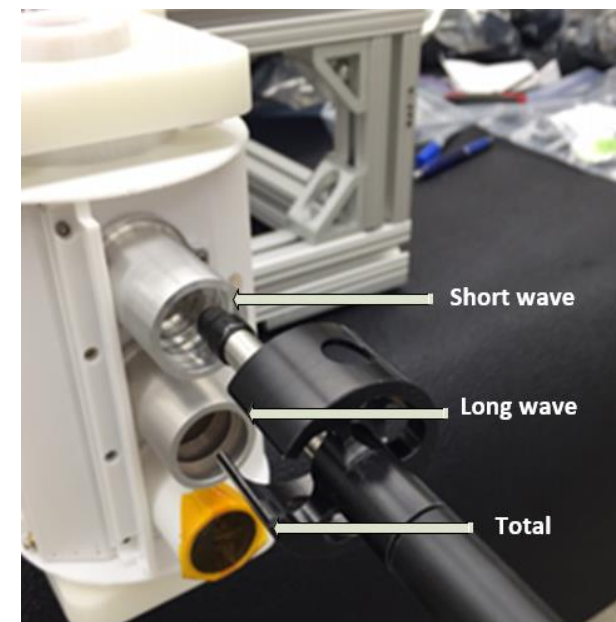
CERES FM 6



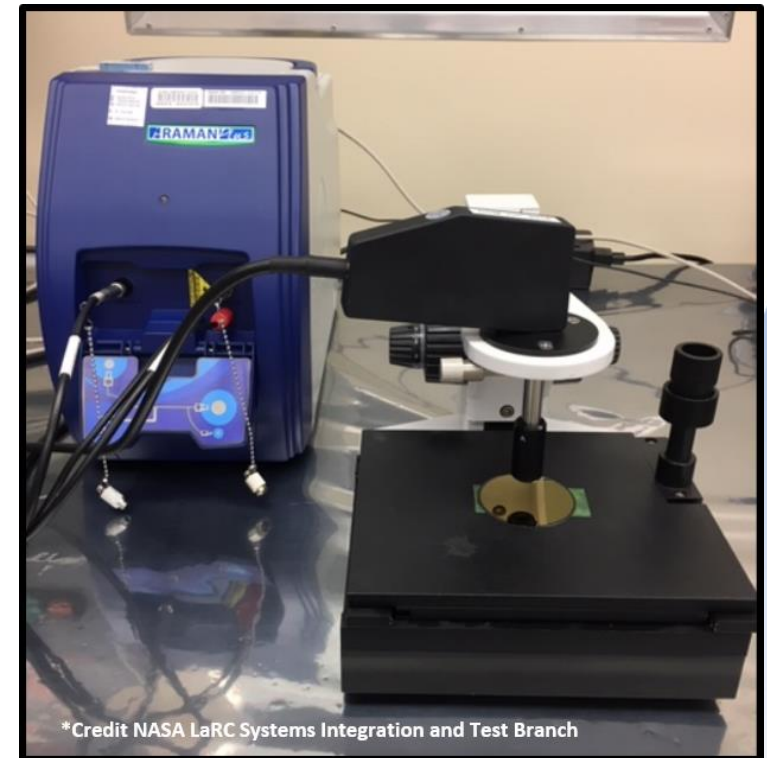
Location of Non volatile residue (NVR) on The CERES FM6 Short Wave Filter



Credit: B&W Tek,
<http://bwtek.com/raman-technology/portable/>



- **More reliable than visual inspection**
 - Saves time if contamination issues are present
- **More details on contamination identification**
 - Properly clean
 - Faster removal
- **Potential early detection of hardware problems**
 - Fix systematic problems
 - Prevent mission/material failure before it occurs



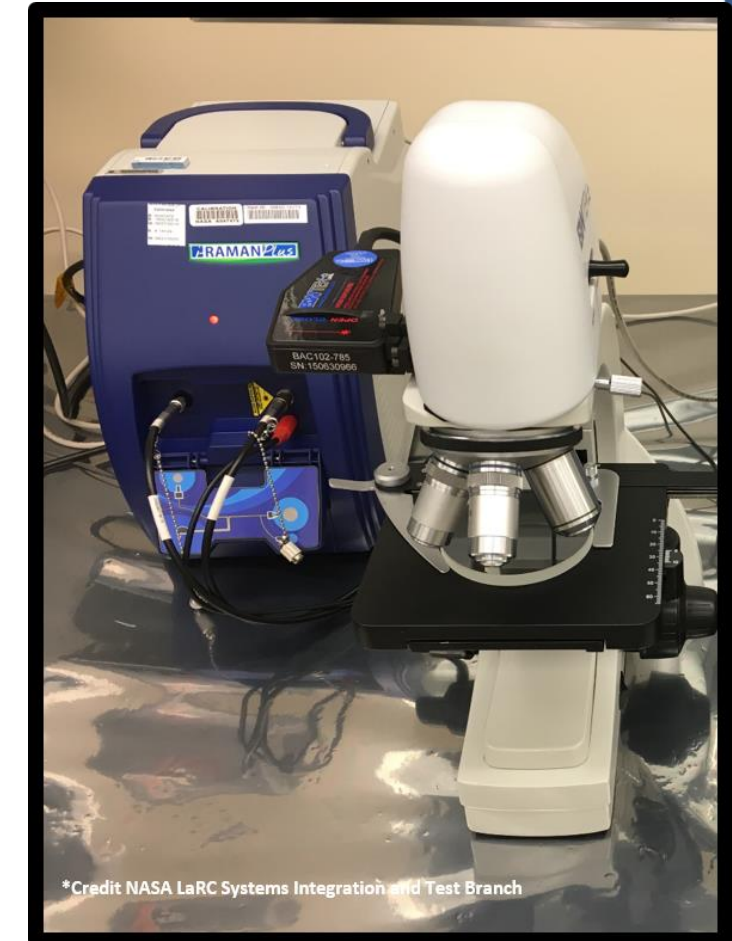


Lessons Learned: Limitations of Raman Spectroscopy

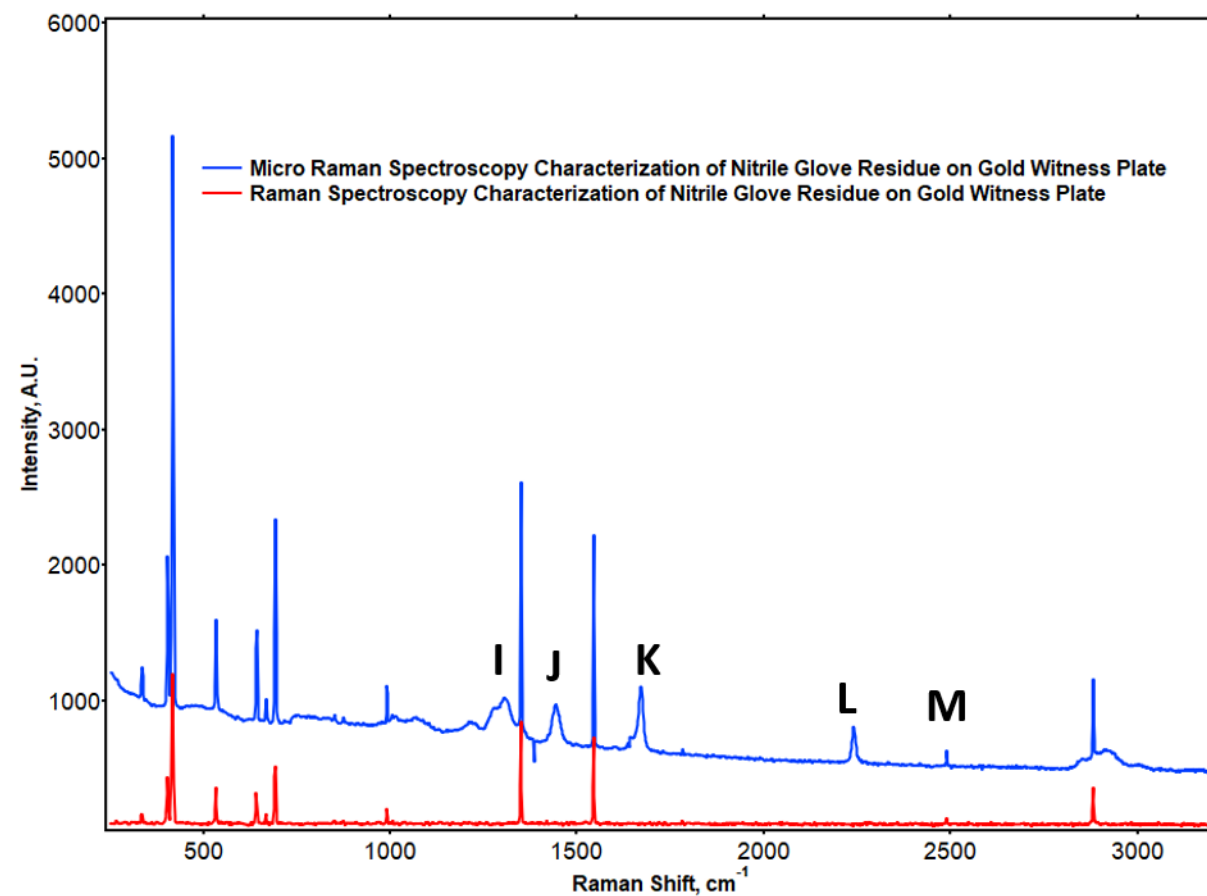
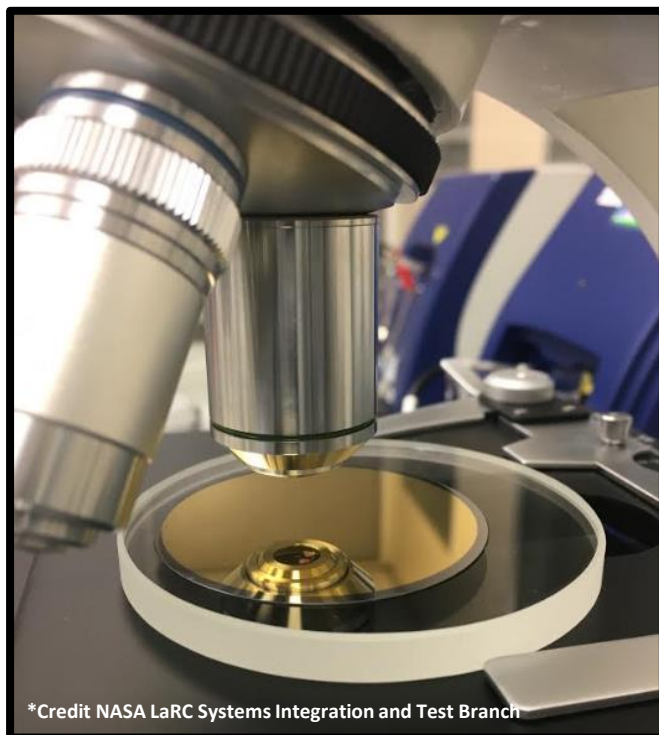
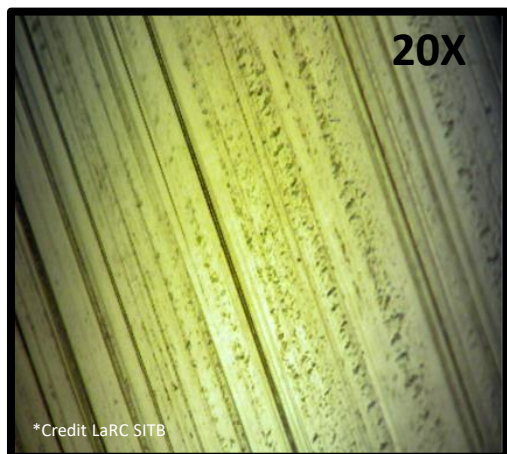


- **Surface of the sample directly impacts scattering**
- **Increasing the power increased the potential to destroy the sample**
 - **Lower power levels required to prevent burning**
- **Inefficiency of Raman scattering, sample fluorescence and substrate spectra masking sample spectra**
 - Gold witness plate is ideal
 - There is a strong affinity for gold and organic molecules such as thiols, sulfur, and carbon
 - The binding affinity of the gold limits the ability to remove monolayers of organic material resulting in a high baseline spectra of the cleaned Au witness plate
 - High baseline spectra of the gold witness plates limits the use to approximately 4-5 times for monitoring hardware
 - Limited use is very costly
- **Initial field work identified the need to explore methods to reduce the baseline spectra of the gold witness plate coupled with Raman spectroscopy**

Type of Monitoring	Pros	Cons
Raman Spectroscopy with Au witness plate	- Limited sample preparation - Adjustable power setting - Ability to sample NVR directly from some surfaces of spacecraft with probe accessory - Spot size with 85 μm	- Unless using a detector card, or sensor viewer the laser spot is not visible - Baseline spectra of Au witness plate can mask the sample spectra
Micro Raman Spectroscopy with Au witness plate	- Limited sample preparation - Adjustable power setting - Smaller pot size (average of 1.5 μm with a 0.55/50X objectives and 785 nm laser) - Ability to map gold witness plate - Enhanced imaging increases ability to capture deposited NVR	- Unable to directly sample from surface of spacecraft

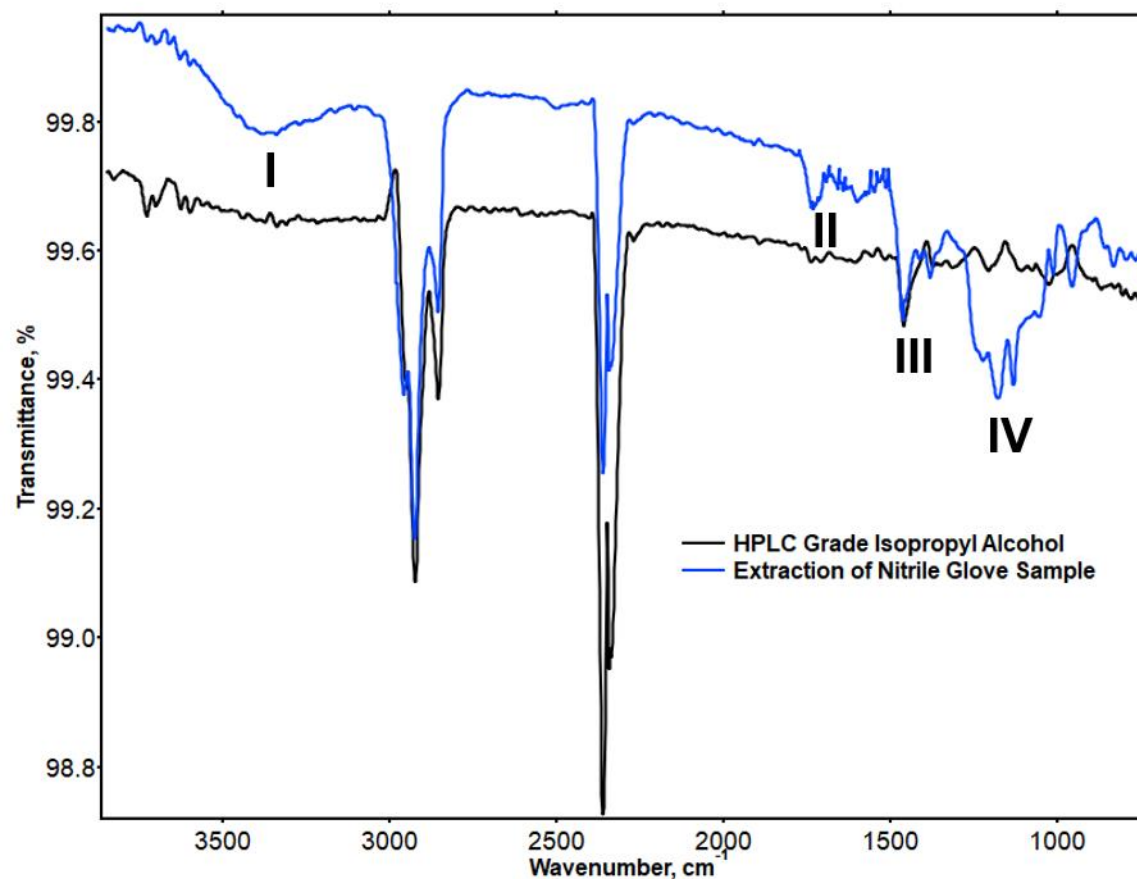


- Several Glove Residue Samples were dried on Au witness plates and characterized with the probe accessory and portable Raman spectrometer
- For comparison, these samples were characterized with micro Raman Spectroscopy under 0.55/50X objective

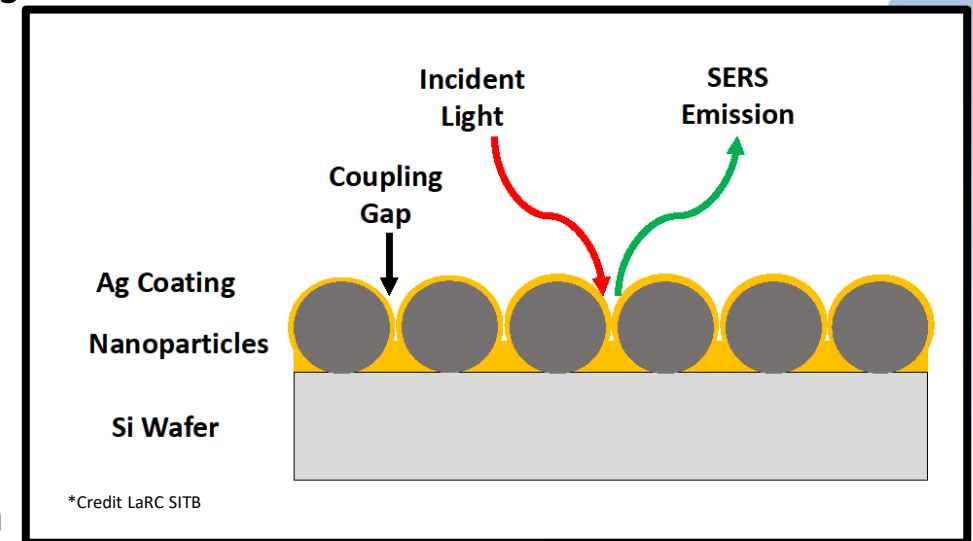


Characterization of Glove Residues with Fourier Transform Infrared (FTIR) Spectroscopy

- **Attenuated Total Reflectance (ATR) Fourier Transform Infrared (FTIR) characterization validated observations from the Raman spectroscopic characterization**



- **Glove residues characterized with micro Raman spectroscopy identified more chemical signatures unique to the material**
- **Validation of the glove residues samples with FTIR aligned with the results form micro Raman spectroscopy**
- **Future work include the following:**
 - Need to explore the limit of detection of contamination with the use of standards and existing samples
 - Explore the potential for mapping witness plates with micro Raman spectroscopy
 - Use of Surface-Enhanced Raman Scattering (SERS) Substrates



SERS Substrate Cross-section



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Questions?