National Aeronautics and Space Administration

Raman Life Detection Instrument Development for Icy Worlds

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Objectives:

The objective of this project is to develop a compact, high sensitivity Raman sensor for detection of life signatures in a flow cell configuration to enable bio-exploration and life detection during future mission to our Solar System's Icy Worlds.

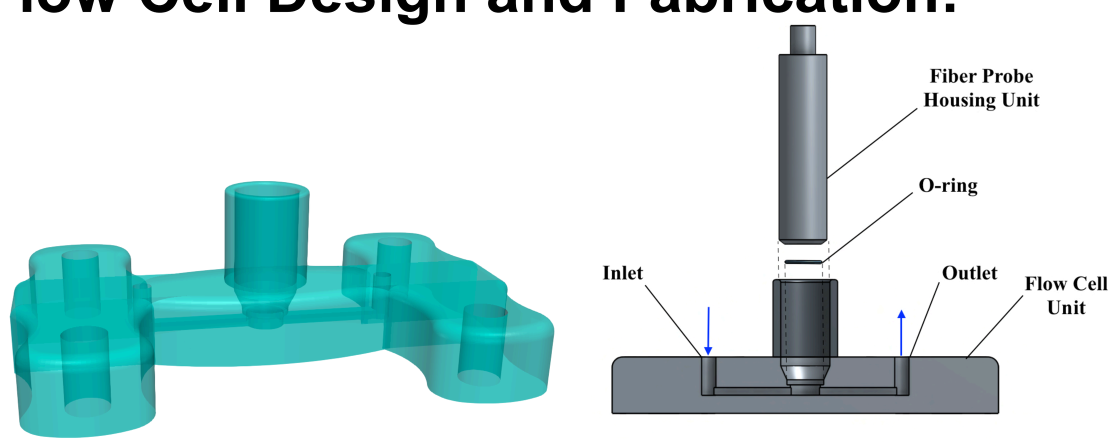
The specific project objectives are the following: 1) Develop a Raman spectroscopy liquid analysis sensor for biosignatures; 2) Demonstrate applicability towards a future Enceladus or other Icy Worlds missions; 3) Establish key parameters for integration with the ARC Sample Processor for Life on Icy Worlds (SPLIce); 4) Position ARC for a successful response to upcoming Enceladus or other Icy World mission instrument opportunities.

Technical Approach:

We propose to develop the 1064 nm fiber laser Raman instrument capability to non-destructively analyze individual, micron-size particles in a synthetic seawater suspension through a 1.8 mm by 0.9 mmm flow channel.

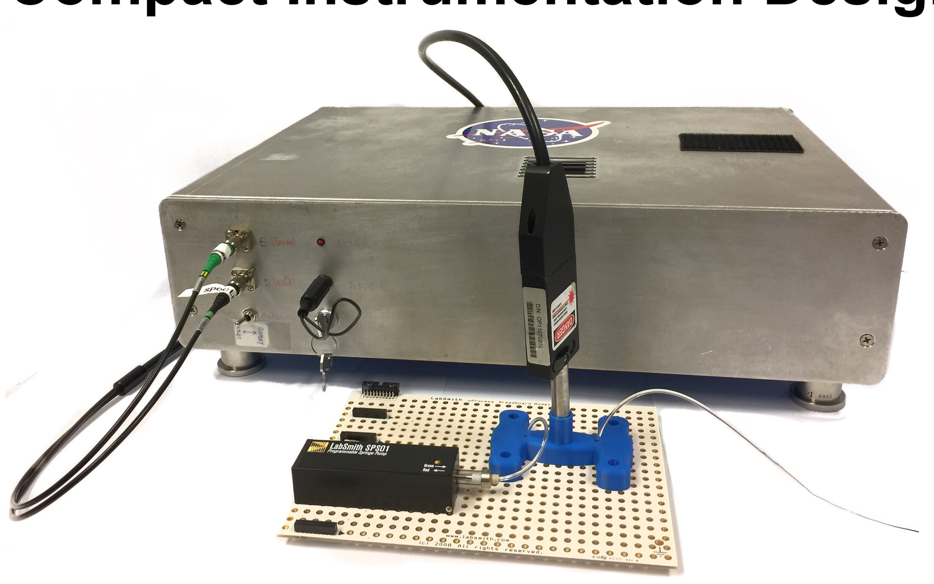
We choose *rhodopseudomonas palustris* as a model life organism for Icy World missions. The fiber Raman instrument was used to measure its molecular marker carotenoids, light harvesting molecules whose levels are regulated according to the amount of light present. Surface roughened hollow gold nanoparticles were used as surface enhancement Raman spectroscopy (SERS) substrates to enhance the carotenoid signal..

Flow Cell Design and Fabrication:



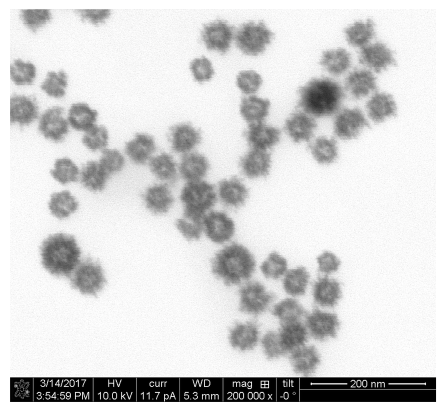
Flow cell was designed using Onshape software and fabricated using a Markforged Onix One 3D printer at the NASA Ames Space Shop.

Compact Instrumentation Design:



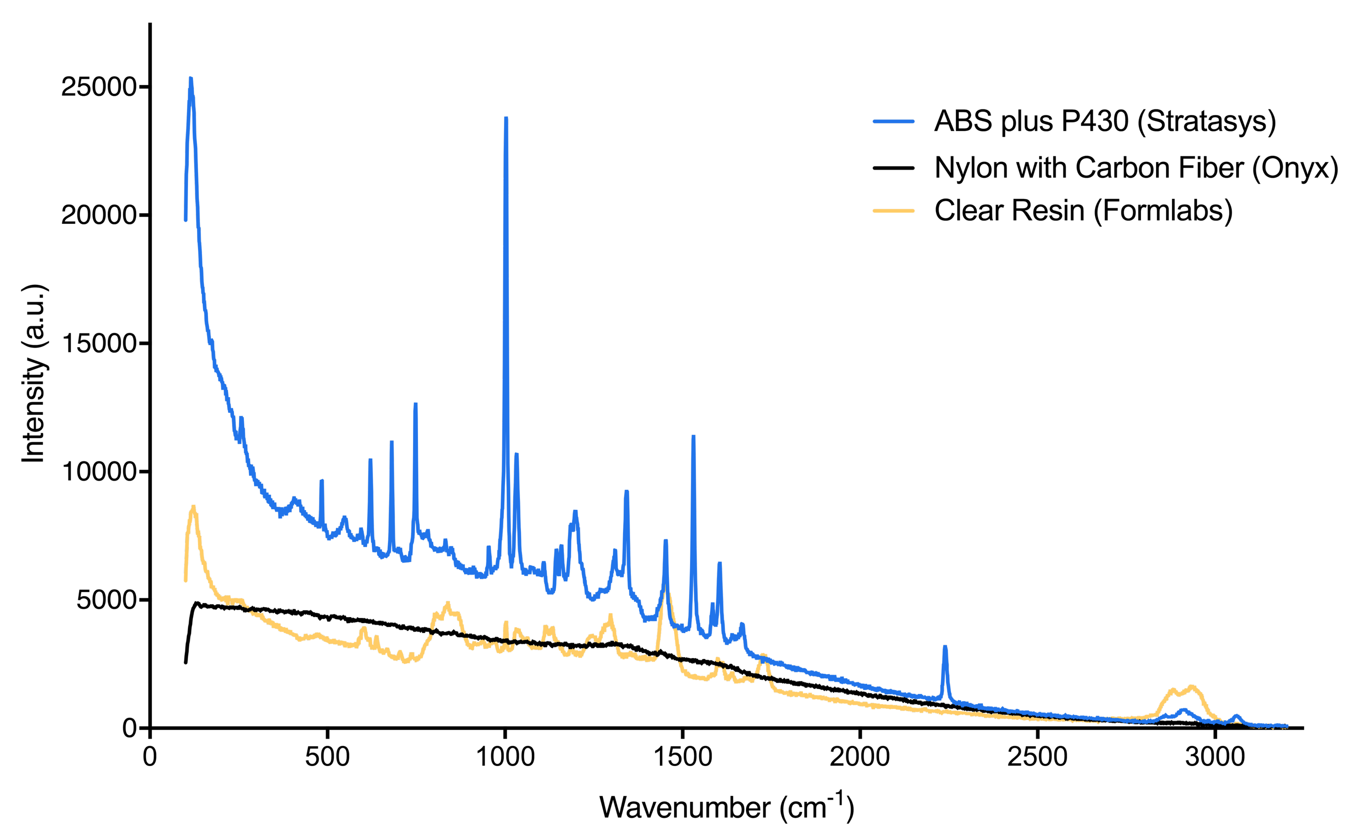
Portable Raman instrument integrated with 3D printed flow cell.

SERS Particle Design:



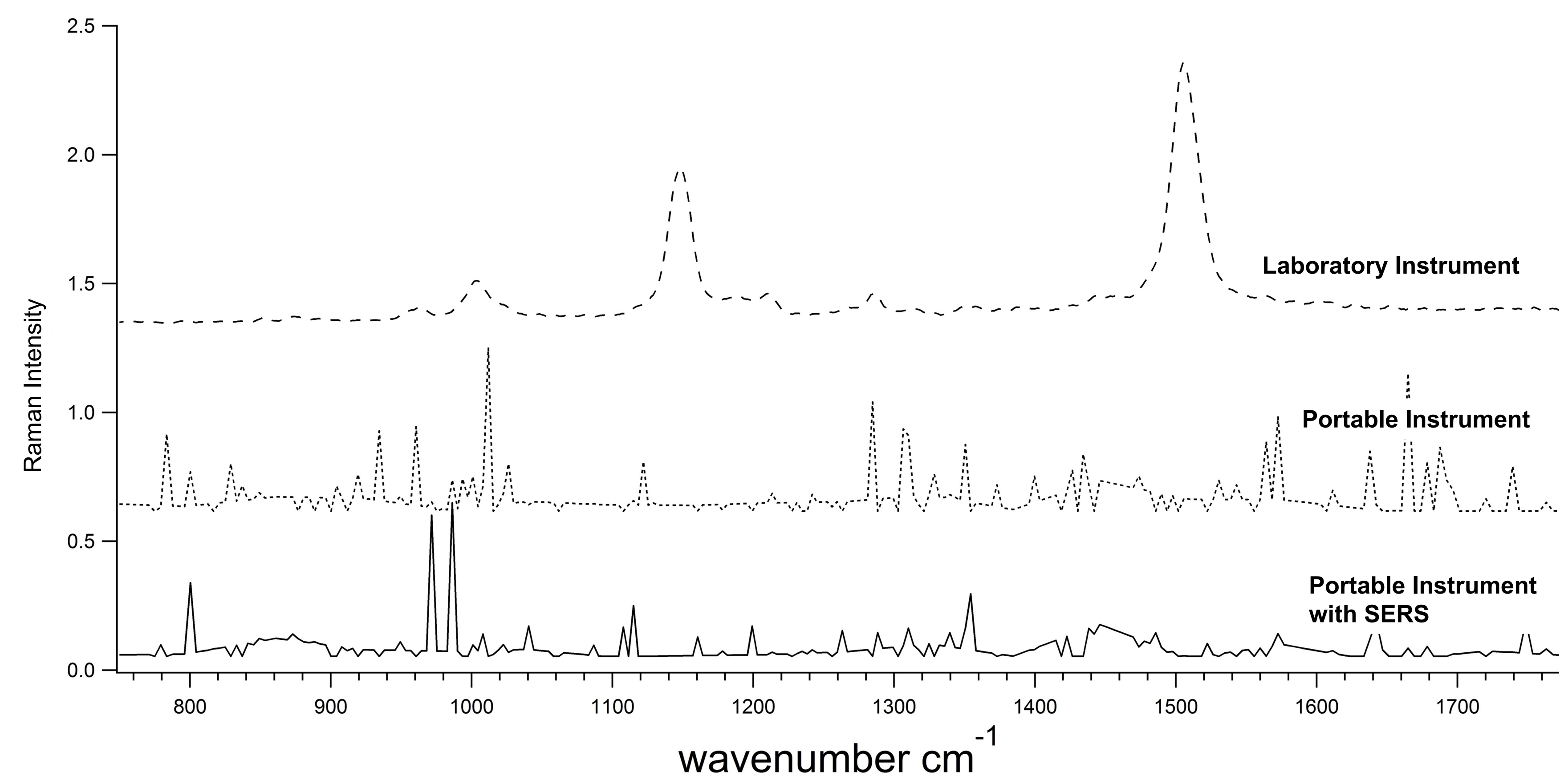
TEM of roughened hollow gold nanoparticle SERS substrates.

3D Printed Materials Selection:



Several 3D printed materials were tested using the 1064 nm laser to determine background signals.

Rhodopseudomonas palustris Detection:



Rhodopseudomonas palustris detection using laboratory and portable Raman instruments with and without SERS substrates.

Fiber Raman Advantages:

- Flexible form factor
- Low power (mW)
- Able to measure liquid sample
- Non-destructive to sample
- 1064 nm excitation minimizes background fluorescence
- SERS compatible

Conclusions and Future Work:

This project demonstrates the application of a fiber Raman sensor for life detection missions. The Raman probe has been integrated with a fluidic channel used to detect carotenoids in a *rhodopseudomonas palustris* sample. Nanoparticles have been added to the flow cell for surface enhanced Raman spectroscopy (SERS). In the future, immobilization strategies of SERS substrates will be investigated to improve measurement reproducibility. In addition, a SERS tip coated multimode fiber will be generated to replace current Raman probe to further amplify detection signal and improve measurement reproducibility. In addition to obtaining Raman spectral information, we aim to use physical manipulation (e.g. particle sorting) using laser tweezers.

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