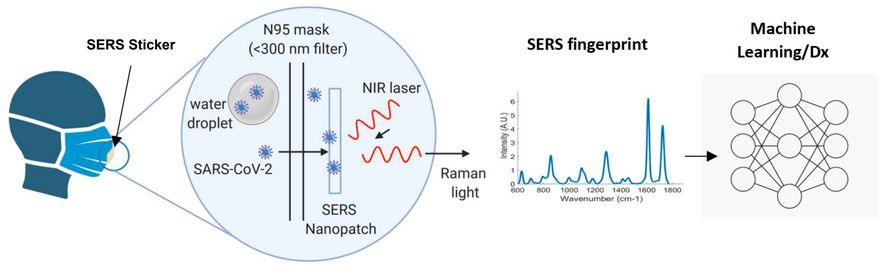
SARS-CoV-2 Screening Using Raman Spectroscopy Enhanced with Flexible Nanoparticle Substrates

Wangcun Jia, Phuong Le, Robert Brown, George M Peavy and Thomas E Milner

Beckman Laser Institute and Medical Clinic, University of California, Irvine

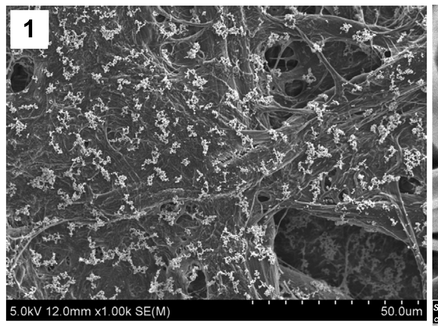
Objective and Vision

- Low-cost, ***SERS sticker*** placed on the inside/outside of facemasks
- Raman spectrometer equipped station to scan facemasks
- Machine learning to indicate the probability of COVID-19 infection
- Detection of other infectious diseases possible

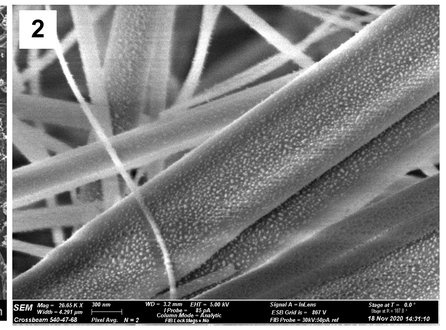


Materials and Methods

- 2 types of substrate : 1) ***Cellulose*** with printed gold nanoparticles; 2) ***Quartz fiber*** with gold nanoparticles formed with inert gas condensation

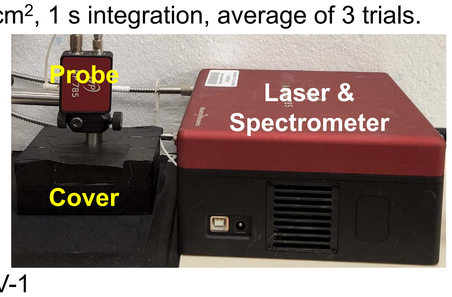


From Ref. 1



Courtesy: Nikalyte Ltd., UK

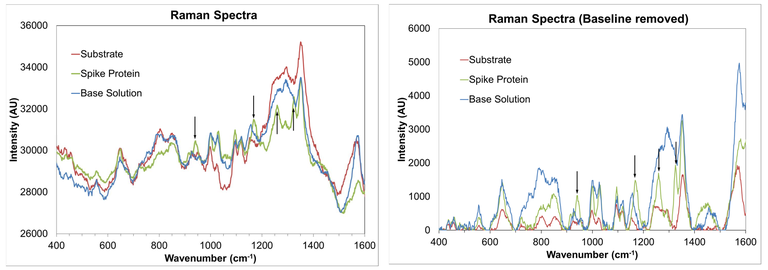
- Raman spectrometer: 785 nm, 20 W/cm^2, 1 s integration, average of 3 trials.
- Virus
  - Spike Glycoprotein of SARS-CoV-2
    - Delta variant
    - 0.25 mg/mL
    - 1:10, 1:20, 1:200 dilution
  - Purified and deactivated SARS-CoV-1
  - Mixture of deactivated SARS-CoV-2 and hosting Vero cells
  - Influenza vaccine
- Base solution alone



References: 1. Yu and White, Analyst, 2013, 138, 3679; 2.

Results and Discussion

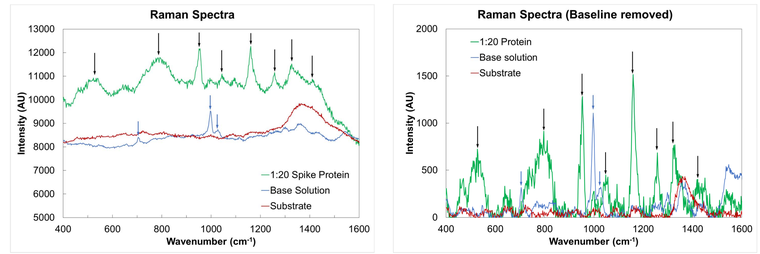
Cellulose substrate



There are many intrinsic peaks in the cellulose substrate. Although distinct peaks (arrows) can be seen with the spike protein solution, they diminished at a dilution of 1:10.

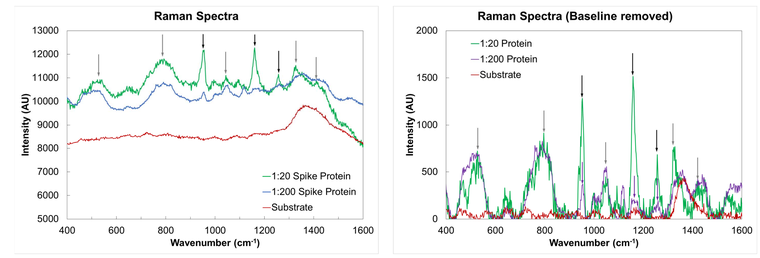
Quartz fiber substrate

1:20 spike protein solution



Much less intrinsic peaks in the quartz fiber substrate (red curves). More distinct peaks (black arrows) with higher signal-to-noise ratio (SNR) can be seen with the spike protein solution at a dilution of 1:20. Location of some peaks are nearly the same as those peaks from the spike protein on the cellulose substrate. Peak locations of the base solution (blue arrows) do not overlap with those of spike protein.

1:20 vs 1:200 spike protein solution

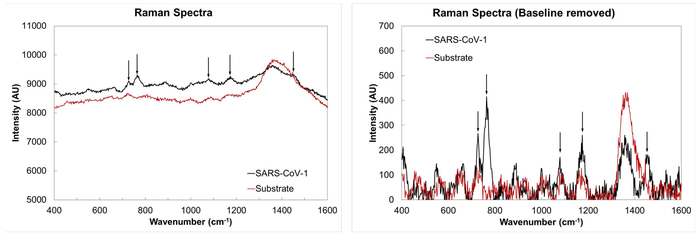


When the protein concentration was decreased to 1:200, some peaks (black and purple arrows) demonstrated concentration-dependent decrease, and some peaks (gray arrows) did not decrease with protein concentration, which may not be intrinsic peaks for the spike protein.

Results and Discussion

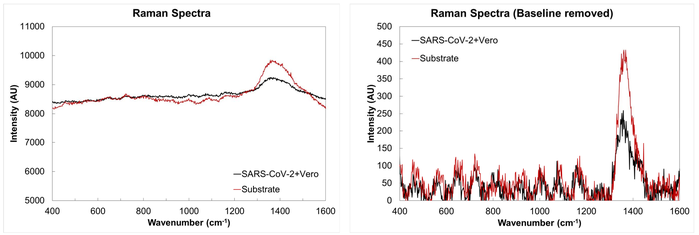
Quartz fiber substrate

SARS-CoV-1



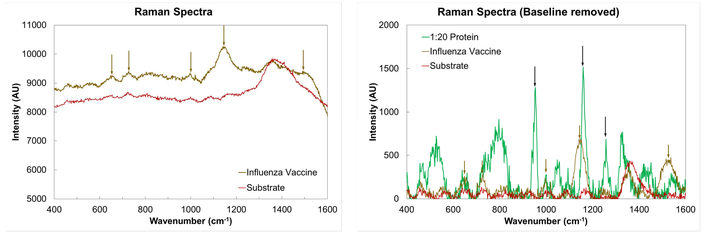
For purified whole virus (SARS-CoV-1), some peaks can be seen but the SNR is lower than spike protein.

SARS-CoV-2 + hosting Vero cell



When a mixture of SARS-CoV-2 virus and the lysed hosting Vero cells were measure, no distinct peaks can be seen.

Influenza Virus



For influenza virus, at least one peak with good SNR can be seen, thought there is clear difference between its spectrum and that of SARS-CoV-2 spike protein.

Conclusions

- SARS-CoV-2 spike protein on a quartz fiber substrate deposited with gold nanoparticles can be reliably detected with Raman spectroscopy.
- The SNR for whole virus including SARS-CoV-1 and Influenza is lower than that of the spike protein. Size of nanoparticles needs to be optimized to increase the SNR for the whole virus.
- Functional nanoparticles may be needed to detect the virus in a complex mixture.

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