A Self Contained Portable Surface Enhanced Raman Scattering Needle Probe

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Raman spectroscopy is a well-known technique for identifying molecular structures. In clinical applications probes have been used to identify these structures within a patient's body. In Surface Enhanced Raman Scattering (SERS) a metallic nanostructure adjacent to the molecules greatly increases the Raman signal strength. We have previously reported improved sensitivity in a probe with the metallic nanostructure at the end of a short single mode optical fiber encased in a needle (Fig. 1).[1]

Unfortunately many clinics have neither the infrastructure nor the technical expertise to support Raman spectroscopy and to analyze the resulting spectra. Such clinics may be found in some rural communities, and on some ships at sea. This work reports a completely contained portable Raman spectrometer incorporating the needle probe and capable of providing an audio phone link to a central station with the necessary expertise.

The laser (Fig. 2) generates 10 mW of light at a wavelength of 532 nm. It is a widely available pointer, requiring two 1.5 volt batteries. The laser light is reflected by a 45^{o} dichroic mirror into a commercially available graded index (GRIN) lens and optical fiber configuration. Gold nanostructures are epoxied to the end of the fiber. Scattered Raman light is collected by the fiber, and passes through the GRIN lens and the dichroic mirror. It is reflected by a second mirror and passes through an imaging lens and a notch filter to a CCD line array detector. The entire structure is hand held and connected by an umbilical cord to a control box containing electronics for the line array and batteries to supply the ± 3 Volts required by the line array and the laser. Results with this configuration will be reported.

The line array converts the Raman spectrum into a series of pixels which are read out consecutively. There are used to modulate a 1 kHz carrier frequency (Fig. 3). This is done over a time period of several seconds to allow a sufficient number of carrier cycles in each pixel. The modulated carrier drives a loudspeaker which transmits the Raman signal over a voice telephone line. At the receiver it will be converted to a conventionally displayed spectrum, examined by an expert, and the results reported back over the telephone line.

[1] S. Basu, H.-C. Hou, D. Biswas, S. Maulik, T. Daniels-Race, M. Lopez, J Mathis, and M. Feldman, *Review of Scientific Instruments*, 88(2), 2017.

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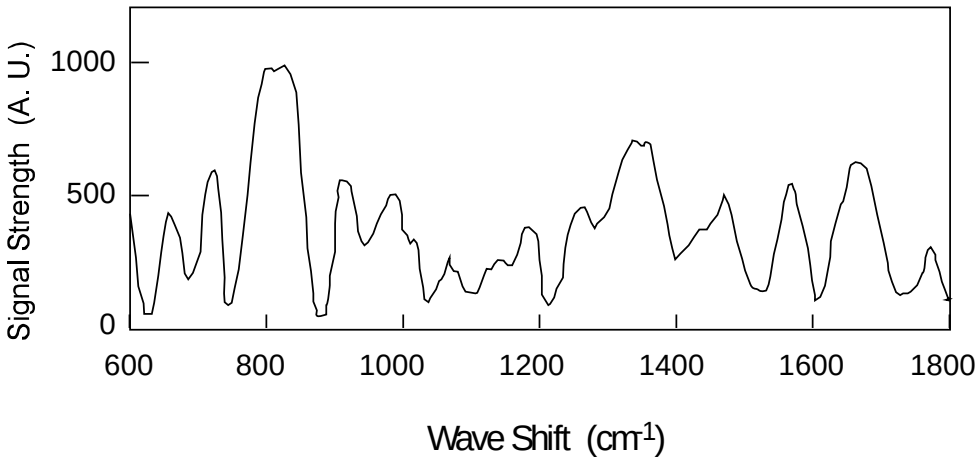

Fig. 1. Raman spectra obtained by a needle probe into cancerous mouse colon. Data were obtained at 633 nm with a LabRAM Spectrometer.

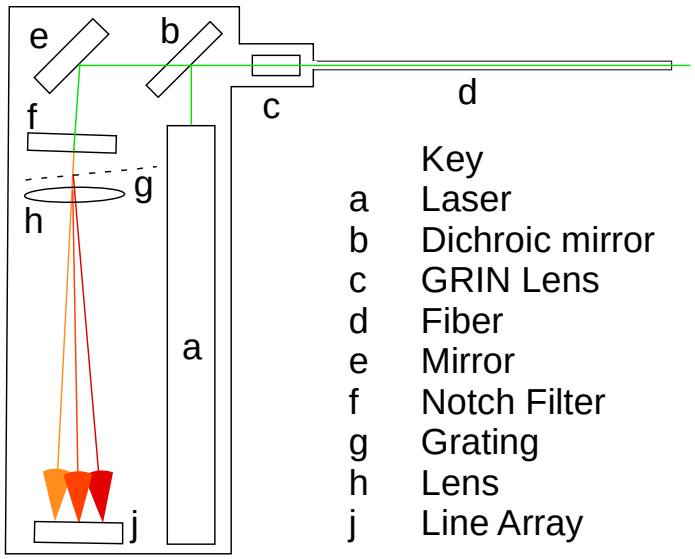

Fig. 2. Hand held Raman Spectrometer probe. The 532 nm laser light is collimated by the GRIN lens and enters the short fiber. Gold nanostructures at the end of the fiber generate Raman light, which passes back through the lens to a line array detector. The dichroic mirror and the notch filter block excess 532 nm light from entering the line array.

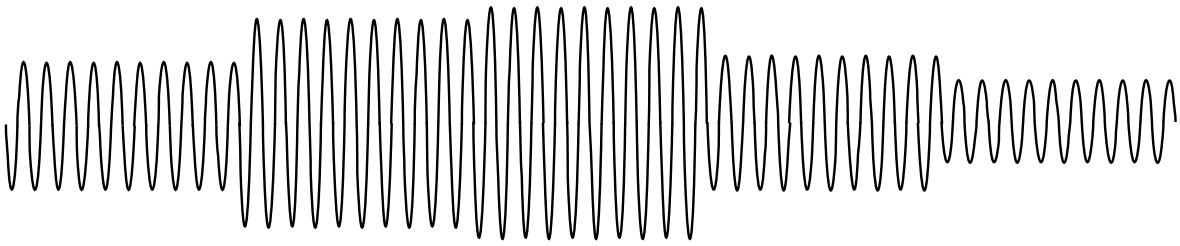

Fig. 3. Schematic illustrating the modulated signal from 5 consecutive pixels around a narrow peak in the line array. The 1 kHz carrier frequency is easily transmitted by an audio telephone.