Designing and Construction of a Research Grade Raman Spectrophotometer on a Budget

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Raman scattering based on molecular vibrational states is a reliable optical phenomenon for identifying and distinguishing a wide range of molecules and related processes. Raman spectroscopy finds useful utility in the detection of narcotics, explosives, monitoring of contaminants in food and pharmaceuticals, disease diagnostics and metrology just to name a few. Although many research grade Raman spectrophotometers are now available commercially, due to demanding device performances, price becomes excessively high. Therefore, the scientific community with tight financial constraints, especially in the developing world, is deprived of such a useful research facility. Here we present an alternative design for a research grade Raman spectrophotometer built with off the shelf optomechanical components without compromising the device performance. Commercially Available Instruments (CAI) provide standard features with further add-ons available at an extra cost upon request. An instrument such as Renishaw inVia™ confocal Raman microscope can accommodate several lasers and corresponding optical filters, a feature which is also available in this custom-built design. Currently our designed system consists of; options for illumination at 532 nm and 785 nm with compatible detection filters for stokes shifted optical signals and two microscope objective lenses including a ×50, 0.42 NA, long working distance compatible with NIR region. Compared to a standard detector size of 1024 pixel × 256 pixel, this design has a 1600 × 200 back-illuminated electron multiplication (EM) CCD for low light detection (with 16 μm pixel size), which also contains a 16-bit ADC that can be operated at 3 MHz with low read noise = 39.8*e*. While the maximum signal count is at 65535, the noise margin lies around 300. The spectrograph consists of a Czerny-Turner geometry containing ruled diffraction gratings of (either 600 l/mm or 1200 l/mm), able to resolve spectra down to 0.1 nm. The system at 532 nm illumination has, therefore, the capability of measuring Raman wavenumbers of up to 4300 cm^{-1}at a resolution of 3.5 cm^{-1} against the 0.3 cm^{-1}, spectral resolution of CAI. The overall cost of construction of the spectrophotometer was approximately USD 86,000 relative to the prohibitively high (>USD 250,000) of a CAI with approximately similar features.

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