Typical imaging spectrometers on the market today are designed based on two primary performance trade-off considerations: maximizing optical throughput ($f/#$) to maximize signal levels with optical fiber and low light, free-optic applications; and achieving optimized spatial and spectral resolution. Unfortunately, standard designs are not necessarily the best solution for micro-spectroscopy.

When equipping a light microscope with standard spectrometers, mechanical and optical design limitations appear. Because most microscope ports are not designed to handle the 15- to 60-lb combined weight of a spectrometer and CCD camera, both instruments must be free standing. Neither microscope nor spectrometer manufacturers have standardized optical-axis heights or coupling mechanisms, however. To accommodate this mismatch, we designed the system to allow fine height adjustment to accurately match the microscope exit focal plane to the input focal plane of the spectrometer and, therefore, the focal plane of the camera. The instruments couple via a video C-mount, which provides enough adjustment for this image plane alignment.

When a CCD camera is directly mounted to a microscope port, it is routine for a microscopist to fully view the sample with the full aperture of the camera CCD chip (typically up to 12-mm square). If we place a spectrometer between the microscope and the camera, the spectrometer entrance aperture and optical design may limit this full view. This is because standard spectrometer entrance apertures are designed for spectroscopy only. They consist of a double-blade slit assembly with a fixed height of about 14 mm and are adjustable in width from about 10 µm to approximately 3 mm.

For our integrated system, we designed a slit with two positions. The imaging position provides a 12-mm × 12-mm square aperture that accommodates straight-through imaging of the sample to the CCD, while the spectroscopy position provides a high-precision, 14-mm-tall slit adjustable from 10-µm to 3-mm wide (see figure). We have also designed an optional 12-mm-tall motorized slit that is adjustable from 10-µm to 12-mm wide.

“A common misconception is that the optical design of a standard spectrometer is compatible with direct coupling to any microscope. This is not necessarily the case.”

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