Ultrafast confocal Raman and Rayleigh imaging

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Scanning Laser Confocal Raman Microscope has become one of the most widely utilized research instruments for materials characterization on the submicron scale. The confocal approach eliminates out-of-focus light, and offers the capability to collect serial optical cross-sections from specimens. The Raman (or Rayleigh) image of the extended specimen can be generated by raster scanning the focused laser beam across a defined area.

Raman microscopy is still slow technique in comparison to fluorescence imaging, although it is widespread. For Raman spectroscopy, the short image acquisition times that are achievable are basically limited by CCD detector operation speed (about 5 ms in practice). The Andor Newton electron multiplying CCD equipped with 2.5 MHz read out amplifier can be read out in 2.3 ms, which is the shortest time for Raman measurement with CCDs. A Raman image consisting of 1000x1000 pixels (=1,000,000 spectra) with 2.3 ms time/spectrum requires 40 minutes at least.

The automated Confotec™ imaging system[1] with a galvanic mirror scanner and fast PMT detectors provides the ability to acquire Raman and Rayleigh images several hundreds of times faster. The time of acquisition of each pixel of the image is only 3 µs, and the total time for 1000x1000 pixels Raman image may be 3 sec only. Measurements are made with photomultipliers in the spectral (Raman) and reflected (Rayleigh) channels simultaneously. To obtain images ultra fast, a special algorithm is realized. The galvano scan controller is programmed on base of the imaging parameters to operate in standalone mode. The formed raster pattern is synchronized with the detection system by sync signals at the beginning of each line. The registration system detects the signals and stores the data in internal memory. Upon completion of scanning process, controller transmits the data via Ethernet interface for visualization.

Some capabilities of ultra fast mapping mode with PMT have been shown at its applications (Figure 1 and Figure 2, for example).

Combination of high speed, high sensitivity and high resolution allows the fast acquisition of reliable data on sample components distribution and their phases. An example of the confocal (1AU) mega pixel (1000x1000 pixels) imaging of a gneissic rock is shown in Figure 1. The data show of anatase (titanium dioxide) distribution and sample surface in the laser reflected light.

The ultra fast imaging capabilities has been used for measurement of carbon fibers (Figure 2). Raman imaging with G band (vibration mode of graphite structure) of carbon fibers have been used for the structural characterization of fibers and their graphitization level.

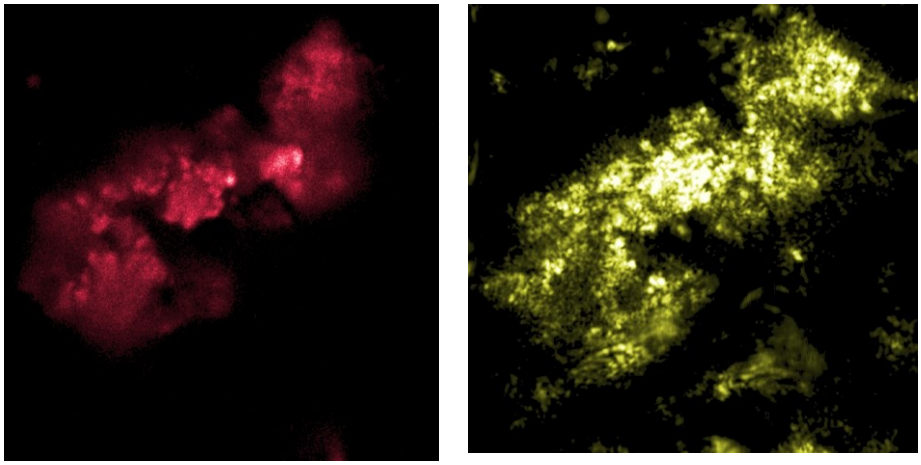

Figure 1. Confocal Raman (on the left) and Rayleigh (on the right) images of a gneiss. Image size is 43x43 µm (1000x1000 pixels), total imaging time is 3sec (1,000,000 acquisitions).

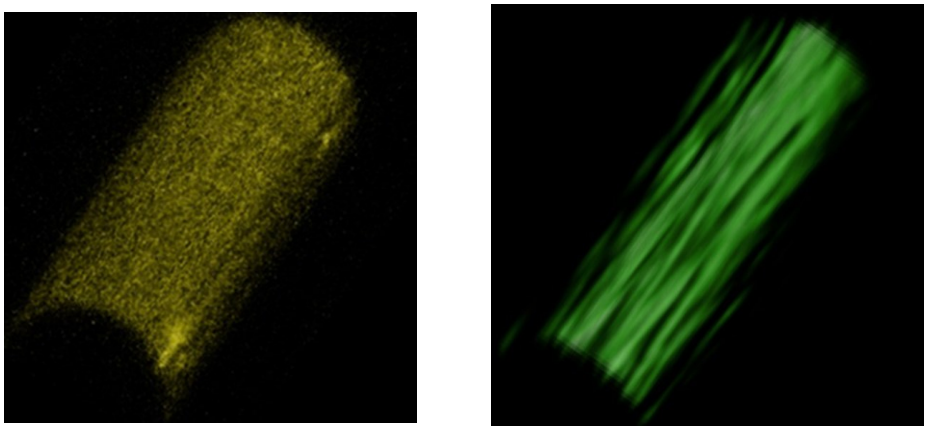

Figure 2. Raman (on the left) and Rayleigh (on the right) confocal images of a carbon fiber. Image size is 21x21x7µm (250x250x70 pixels), total imaging time is 90 sec (4,375,000 acquisitions).

[1] SOL instruments, *Confocal Raman Microscope*, available on http://www.solinstruments.com/en/analysis/microscopy.