L-9836-3401-01-B SPD122PN July 2008
Product note from the Spectroscopy Products Division

RENISHAW apply innovation™

StreamLine™ Plus: Raman chemical imaging just got faster

Fast chemical imaging

The new StreamLine Plus technology from Renishaw enables you to produce Raman chemical images far faster than has been possible before. Raman images that used to take hours to produce can now be created in minutes.

StreamLine Plus

StreamLine Plus technology is available as an option for Renishaw inVia Raman microscopes.

It comprises proprietary hardware and software that dramatically increase the speed of data acquisition, whilst maintaining excellent spectral quality.

How does StreamLine Plus work?

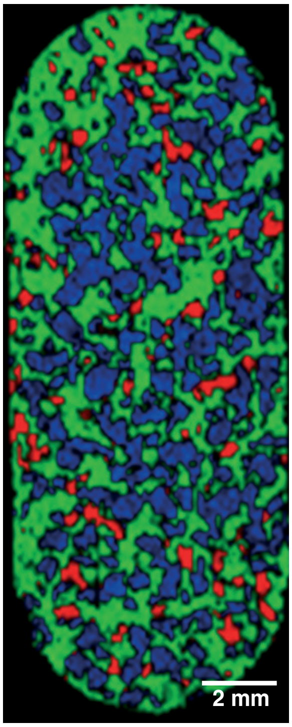
StreamLine Plus combines advanced optics, mechanics, and detector technologies.

StreamLine Plus uses optics within the inVia Raman microscope to illuminate a line on the sample. The inVia's motorised microscope stage moves the sample beneath the objective lens so that the line is rastered across the region of interest. Data are swept synchronously across the detector as the line moves across the sample, and are read out continuously.

Spatial resolution

StreamLine Plus's spatial resolution is determined by the choice of microscope objective and settings in the Renishaw WiRE software.

Users can select any resolution from sub-micrometre to millimetre. A single objective can be used to provide data at different spatial resolutions: for example, a 20× objective can give spatial resolutions from 3 µm to over 150 µm.



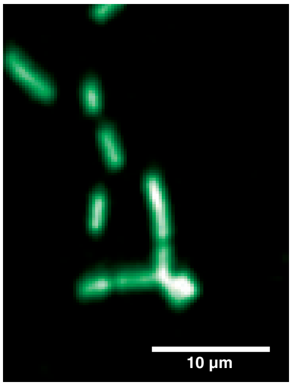
StreamLine Plus Raman image of a pharmaceutical tablet, acquired in only 4 minutes.

Pharmaceuticals: tablets

Raman spectroscopy is used extensively in the pharmaceutical industry, for tasks such as polymorph identification. In this example StreamLine™ Plus Raman imaging is used to identify the distribution and domain size of the active ingredients in a sectioned analgesic tablet.

Colour coding:
caffeine (red);
aspirin (green);
paracetamol (blue).

A 20× objective was selected to image a complete tablet, measuring approximately 18 mm by 7 mm, in 4 minutes. The image clearly reveals the distribution of the three active ingredients.

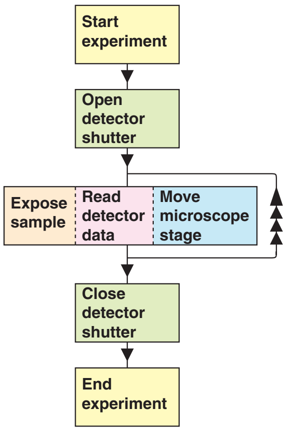


StreamLine Plus Raman image of *Bacillus cereus*.

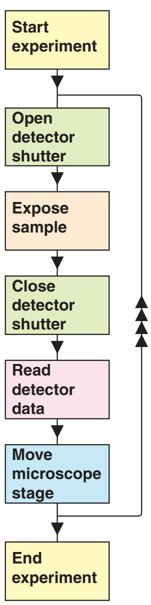
Biology: bacteria

Image of *Bacillus cereus*, a soil dwelling bacteria that can cause food-borne illness, in its vegetative state.

The Raman spectra acquired to create the image can be used to distinguish bacillus cereus from other bacteria.



Steps involved in StreamLine Plus data acquisition



Steps involved in point-by-point data acquisition

Excitation wavelengths

StreamLine Plus can be used with any of the excitation wavelengths supported by inVia Raman microscopes.

This allows users to select the optimum excitation wavelengths for each of their applications, ranging from the ultraviolet to the near-infrared.

Imaging large areas

StreamLine Plus is not limited to the field of view of the microscope - you can image as large an area as your motorised microscope stage allows.

The ability to image areas larger than the field of view of the microscope not only enables large areas to be imaged, but it also allows areas to be imaged using high magnification objective lenses. These have high numerical apertures and hence high optical efficiencies; this minimises experiment times.

StreamLine Plus's scanning method creates large artefact-free images; there is no need to tile together a large number of smaller images.

Fully covered

StreamLine Plus's scanning method gives 100% coverage of the region of interest on the sample, ensuring the Raman data are fully representative.

StreamLine Plus can gather data from the whole of the region selected for imaging by the user. There are no missed areas, so that even small features will not be overlooked.

Why is StreamLine Plus so fast?

StreamLine Plus is fast because sample movement, sample illumination, and data readout are performed simultaneously, rather than in series. StreamLine Plus's larger illuminated area also enables the maximum laser power to be exploited.

Traditional point-by-point Raman mapping systems operate in a sequential manner, in turn opening the detector shutter, collecting the scattered light, closing the shutter, reading the data, moving the sample. This sequence may be repeated many thousands of times as the data for the image is acquired.

StreamLine Plus, in comparison, opens the shutter once, at the start of the experiment, and closes it once, at the end of the experiment. In between these two operations, sample movement, light collection, and data readout occur continuously, and in parallel.

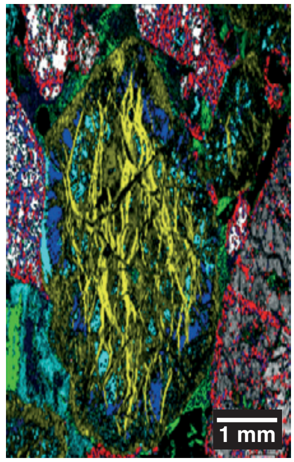
Point illumination systems are also often restricted to using a fraction of their available laser power because the small illuminated area results in an extremely high power density, damaging or modifying the sample.

StreamLine Plus's line focus sample illumination geometry gives lower power densities, enabling the maximum laser power to be employed. This ensures high data quality is maintained even at very fast acquisition speeds.

StreamLine Plus is the only mapping technique that gives this power density reduction whilst maintaining high spatial resolution.

inVia Reflex Raman microscope

Microscope image taken with crossed polarisers.



StreamLine Plus Raman image.

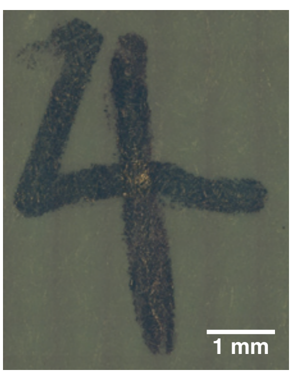
Minerals: images of igneous rock

Sample is a section of ultramafic igneous rock from Tibet showing hydrothermal alteration (talc and serpentinite are replacement/alteration product sheet silicate minerals).

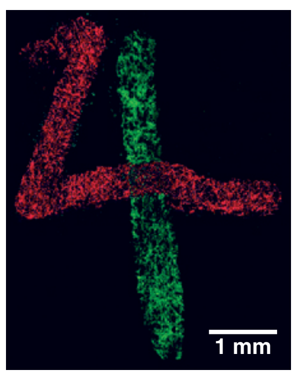
6 components were identified from the Renishaw Inorganic Materials Database.

anatase (red)
biotite: iron-rich sheet silicate (green)
amphibole: rock forming aluminosilicate (cyan)
talc: sheet silicate (blue)
serpentinite: sheet silicate (yellow)
pyroxene: rock forming aluminosilicate (grey/white)

The microscope image is a montage of cross polarised white light images.



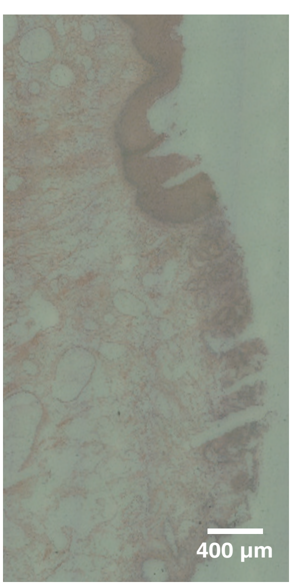
Microscope image.



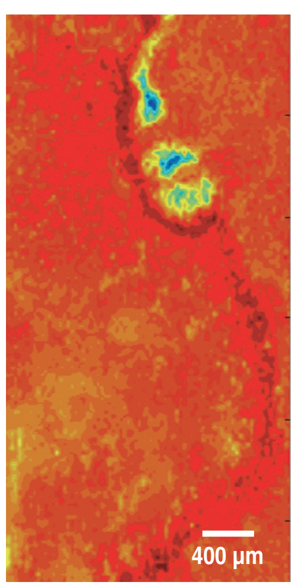
StreamLine Plus Raman image.

Forensics: questioned document analysis

Whereas the microscope image shows what appears to be a handwritten number four, the StreamLine Plus Raman image reveals that a different pen has been used to doctor a number one into a four. The StreamLine Plus image also shows that the number one was written first.



Histological section.



StreamLine Plus Raman image.

Medical: oesophageal tissue section

Raman spectroscopy can be used to distinguish between normal, pre-cancerous, and cancerous cells.

This Raman image, generated from StreamLine Plus data analysed using multivariate techniques, reveals normal squamous regions (blue), and Barrett's mucosa regions (dark red).

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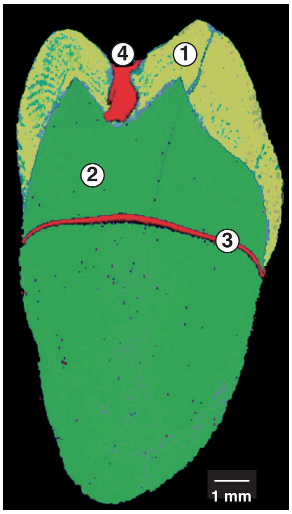
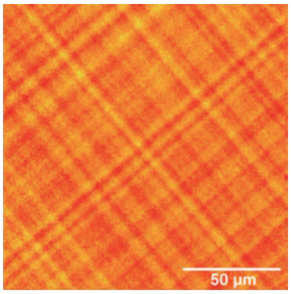


StreamLine Plus Raman image of a complete tooth section, showing regions of enamel (1), dentine (2), the CEJ (3), a carious region (4).

Medical: image of a sectioned tooth

An image of a sectioned tooth, derived from more than 84,000 spectra that were acquired in less than one hour. StreamLine Plus's line-focus illumination geometry allowed the use of 150 mW of 785 nm laser power, a power level that destroys tooth dentine when point laser illumination techniques are used. Point-by-point imaging would have required over 24 hours to get the same result.

The Raman image identifies the main regions in the tooth section; enamel (coloured yellow); dentine (green); a horizontal fluorescent feature (the cementoenamel junction, CEJ)(red); and a carious region (red) at the top of the tooth.



StreamLine Plus Raman image of stress in a graded SiGe layer on Si.

Electronics: image of semiconductor device

This image is of a graded silicon and germanium (SiGe) layer deposited onto a silicon substrate, created by plotting the shift in the position of the Si-Si vibration band. The layer is graded such that the germanium fractional content increases from the substrate layer towards the surface.

The strain is generated by the substitution of germanium atoms for silicon atoms, giving rise to a mismatch in the crystal lattice. The crosshatch strain pattern is formed at the surface of the Si-Ge layer as non-homogeneous strain relief occurs. The maximum shift of the Si-Si vibration band (0.2 cm^{-1}) corresponds to a strain of approximately 0.1 GPa.

Prof. Duncan Graham
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Pure and Applied Chemistry,
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“The new StreamLine Plus mapping capability has opened new avenues for our research due to the ability to obtain high quality spectra from a large area in a short time and due to the line scan, with minimal sample damage. The mapping works equally well on biological cells and inorganic surfaces and really takes SERRS and Raman mapping to the next level.”