HORIBA Scientific

Technical Note

Raman

RA-TN04

DuoScan™ Imaging

The innovative DuoScan™ Imaging system extends the imaging capabilities of HORIBA Scientific's Raman instruments from sub-micron to macro-scale mapping. Generating confocal images becomes faster, easier and more flexible, from the deep UV to the IR.

Principle

The Raman microscope has become a powerful analytical tool for many applications including pharmaceuticals, polymers, semiconductors, forensics and life science. The new generation of Raman microscopes offers a non-destructive and non-contact method of sample analysis at the micron level. More particularly, Raman imaging provides the spatial distribution of the various molecular species within a heterogeneous sample, making it possible to produce fast and accurate «chemical» images. The mapping capability is normally achieved by scanning the sample beneath a finely focused laser beam, typically using a motorized stage or a piezo stage. The image is then reconstructed by processing the spatial and spectral data via HORIBA Scientific's sophisticated LabSpec software.

The **DuoScan™ Imaging** technology available on the instruments of the LabRAM Series introduces a new imaging mode, based on a combination of scanning mirrors that scan the laser beam in a pattern chosen by the operator: **a line** for linear profiles, or **an area** for two-dimensional mapping (Fig.1).
The use of scanning devices for mapping is usually limited to visible light since refractive elements placed on the beam path cannot be used outside this range. The DuoScan™ system extends this operational range, enabling mapping **from the deep UV to the Infrared** (in the limits of the microscope objective capabilities).

Moreover, the unique combination of the DuoScan™ technique with **True Confocal** design allows the Raman microscope to scan very small sample areas or volumes with unsurpassed lateral and axial resolution.

DuoScan™ Imaging provides **three modes** of operation depending on the analysis requirement, explained on the next page.

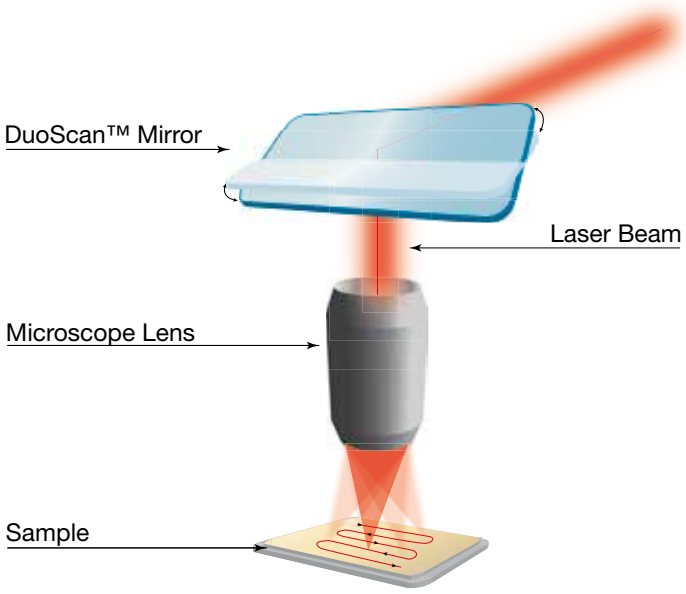

Fig. 1: DuoScan™ principle of operation

DuoScan™ Imaging Features

- Fast and uniform scanning over very small and very large areas
- Map area in step-by-step mode: 30 µm x 30 µm with a 50X microscope objective
- Compatible with True Confocal microscopes for high axial resolution
- Operating spectral range from 220 nm to 1600 nm
- Minimum scanning step: 50 nm with a 50X microscope objective

From sub-micron to macro, from UV to IR, we've got your sample covered!

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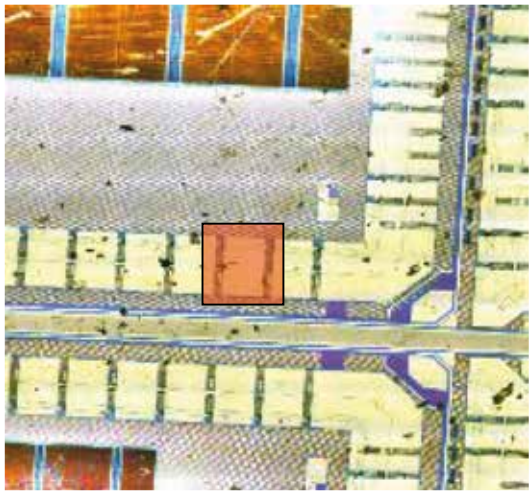
Averaging mode

In averaging mode, the laser spot is continuously scanned across a user-defined square surface. Since the energy of the laser beam is spread out, instead of being concentrated in a small laser spot (Fig. 2), this technique is particularly interesting for sensitive samples which could be altered by photochemical modifications, heating, burning, etc.

The Raman signal is collected over an area **from 1 µm² to 900 µm²**, depending on the objective used, allowing **average measurements** with a macro spot, but maintaining confocality and high collection efficiency due to high NA objectives.

A - Microspot
Spot: 1 µm x 1 µm - Power: 10 mW
Power Density: 10 mW/µm²



B - Macrospot
Spot: 20 µm x 20 µm - Power: 10 mW
Power Density: 25 µW/µm²

Fig. 2: Comparison between standard point measurement and DuoScan™ averaging mode with corresponding laser spot size and power densities on sample.

Step-by-step mapping mode

In step-by-step mapping mode, a sample area is selected and the sample is scanned **point by point** across the chosen area. The sample doesn't move, it is the laser that moves across the sample, making it possible to record fine mapping even on bulky or hard-to-move samples.

The extreme accuracy of the scanning system, comparable to that of a piezo stage, allows stable and repeatable displacement of the laser beam down to 50 nm. Images can be generated in high definition for optimal resolution (Fig. 3).

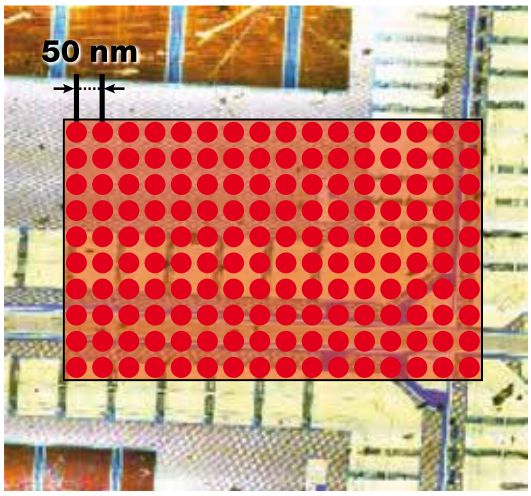


Fig. 3: Mapping without moving the sample, with 50 nm step size.

Macro-mapping mode

When looking at large sample surfaces, whether it is to measure component distribution or to search for contaminants, it often comes down to finding a needle in a haystack. The laser beam is **raster-scanned** to record an average spectrum across a variable-size area, and the sample is moved by the motorized stage with a step matched to the scanned area size to **cover the whole surface**.

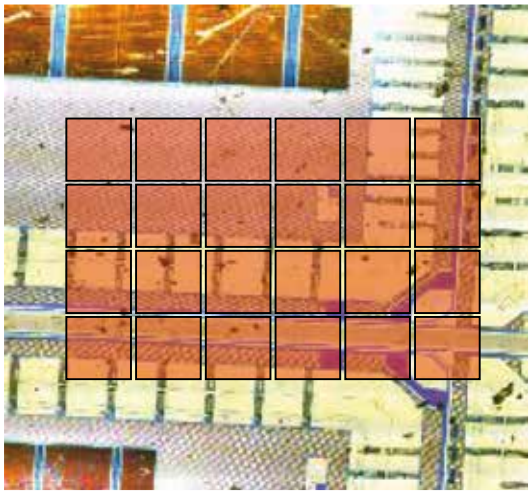


Fig. 4: Macro-mapping mode with full sample coverage using DuoScan™ (with motorized stage).

Application examples

Example 1: Finding isolated SWCNT dispersed across a large surface

Macro-mapping mode is a good way of performing survey scans to find small objects over a large surface. Once a region of interest has been identified within the sample, a more accurate mapping can be performed in step-by-step mode as described above.

In this study, we searched for isolated Single-Wall Carbon Nanotubes (CNTs) grown parallel to one another on a Silicon sample. The CNTs are about 1 nm in width and are separated by about 500 µm.

Figure 5 shows macro-scale image of the sample (full width >1 mm) obtained in macro-mapping mode. The colors correspond to the integrated intensity of the Si band (red) and of the respective G bands of the CNTs (green and blue).

Once the CNT of interest has been located, a high-definition image of the CNT is then obtained by zooming in with DuoScan™ in step-by-step micro-mapping mode (inset). In that case, the apparent width of the CNT (366 nm) is a convolution of the tube diameter with the laser spot size. This shows the superior spatial resolution achievable with a confocal microscope.

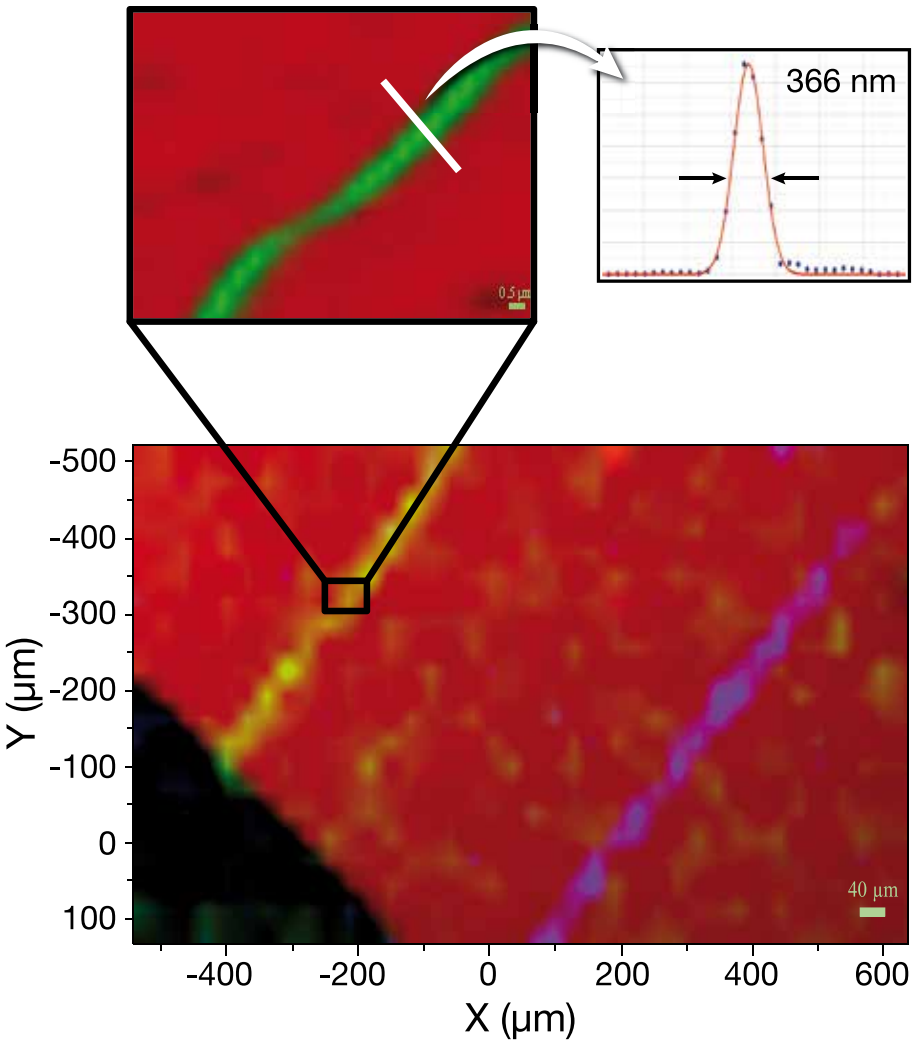


Fig. 5: Macro-map and zoomed-in step-by-step map of a CNT obtained with DuoScan™.
(Sample courtesy of Dr Kalbac, Heyrovský Institute, Czech Republic)

Example 2: Component distribution on a pharmaceutical tablet

Macro mapping can be used to look at component distribution on very large pharmaceutical samples. In this example, a 17.5 mm by 7 mm pellet was analyzed. As the DuoScan™ automatically matches the image pixel size to the scanned area, the full surface is covered, ensuring no spot is missed.

As with the previous example, step-by-step mapping can be performed on a region of interest to look at finer details (Figure 6).

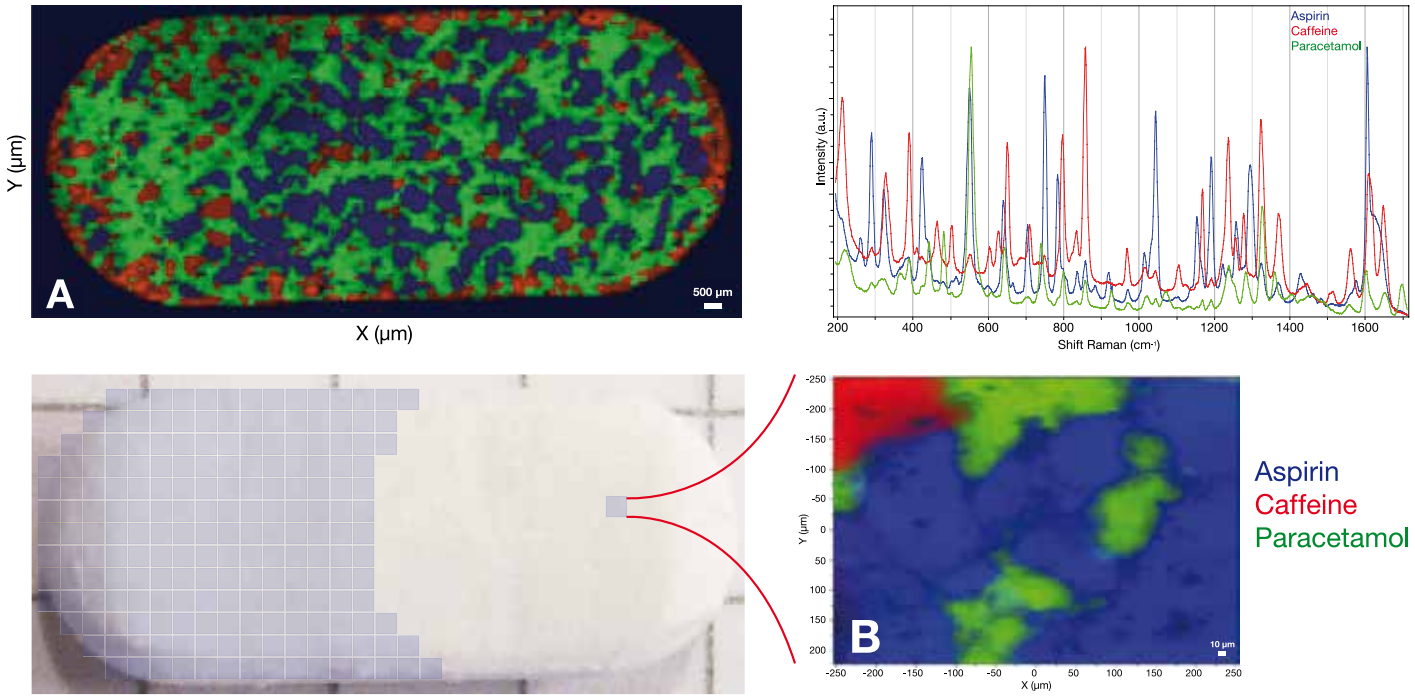


Fig. 6: Raman maps from a pharmaceutical tablet

(A) Macro-mapping, 8240 macro-points, total time 400 s (full tablet)
(B) Step-by-step image of a region of interest, 10000 points, total time 13 minutes (500 x 500 µm).

Web links:

- http://www.horiba.com/scientific/products/raman-spectroscopy/raman-imaging/duoscan/
- http://www.horiba.com/scientific/products/raman-spectroscopy/raman-imaging/duoscan/duoscan-application-examples/

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