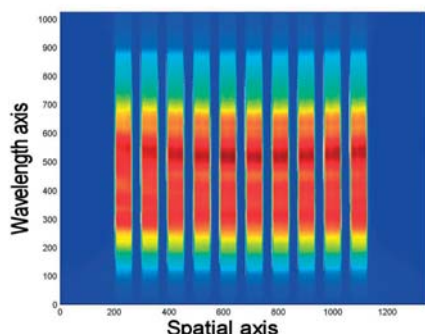


MULTIPLE-POINT SPECTROMETERS

Hyperspectral camera is capable of working, without any moving parts, as a multiple-point spectrometer by coupling fiber optical probes to the camera input.



High speed VNIR Spectral Camera operating in the 400 to 1000 nm region with 10-channel fiber optics.



Spectral signals from the 10 fiber probes on the detector array of the VNIR camera above. Colors code the signal intensity.



NIR Spectral Camera operating in 900 to 1700 nm with 100 fiber optical probes.

HOW DOES IT WORK

SPECIM ImSpector imaging spectrographs and Spectral Cameras are push-broom type hyperspectral imagers, and offer the versatility to work as

- a line imaging spectral camera when equipped with a fore objective lens, and
- a multiple-point spectrometer with multiple optical fiber probes coupled to the input.

In the second option, the ends of the optical fibers are arranged in a linear array, and coupled directly to the input slit of the camera. The spectrum from each fiber is projected on the camera's 2-dimensional detector array, and simultaneously recorded. This implementation turns the hyperspectral camera to a multiple-point spectrometer which is capable of measuring the full spectrum from each probe exactly at the same time. It works without any moving parts, like a mechanical multiplexer which is commonly used to couple multiple probes to a single channel spectrometer.

APPLICATION VERSATILITY

The multiple channel fiber optical design is very flexible to adapt it to various application requirements in terms of

- number of probes,
- length and optical diameter of the probes, and
- termination of the probes with various light collection optics.

Fiber with core diameter from 60 μm to 1000 μm can be used. The input slit is needed to set the desired spectral resolution. Optimized performance is achieved by attaching slit directly on the linear array of the fiber ends.

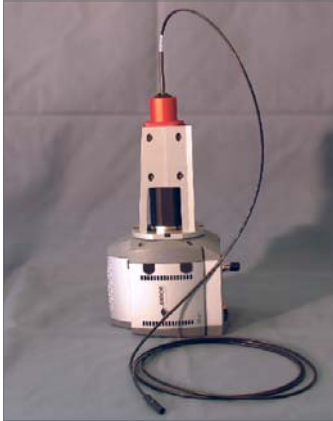
The maximum number of fibers per camera is determined by the spatial dimension of the detector array and diameter of the fiber used. Assemblies of 2 up to 100 fiber probes are successfully integrated into a single camera.

Key benefits

- Quick, simultaneous spectral measurement in multiple positions
- No moving parts
- Single spectrometer to calibrate and maintain.
- Reduced cost and maintenance in comparison to multiple separate spectrometers

Applications

- Color measurement
- NIR chemical analyses
- Quality assurance
- Process control
- Simultaneous multi-angle (goniometric) spectral measurement



EMCCD camera combined with ImSpector V10E imaging spectrograph and imaging probe consisting of 8x8 optical fibers.

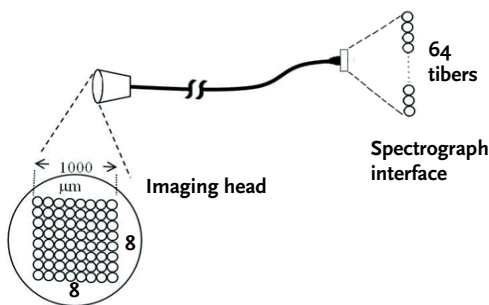
It is advantageous to maximize the fiber core diameter for efficient light collection. Also, the spectrum from a thicker fiber illuminates more columns on the detector array, and averaging the column signals improves the signal-to-noise ratio in the recorded spectrum.

The length of the fiber probe is basically limited only by the spectral transmission characteristics of the fiber material. The probe legs can be terminated with an SMA or other connector or a ferrule, and coupled to an application specific light collection optics.

SNAP-SHOT 2D SPECTRAL IMAGING WITH FIBER OPTICS

With a special fiber optical assembly, a push-broom line imaging camera can acquire snapshot 2-dimensional spectral images. It requires a fiber optical assembly where the individual fibers are arranged in a matrix, like 8x8 array in the imaging head. On the spectrometer interface, all the fibers are arranged to a linear array in a way that the fibers from the first row in the matrix make the first fiber in the linear array, and are followed by the fibers from the second row in the matrix, and so forth. The fiber optical assembly makes a matrix to linear array converter. It provides the benefit of acquisition of a 2-dimensional spectral image at moderate spatial resolution in a single shot.

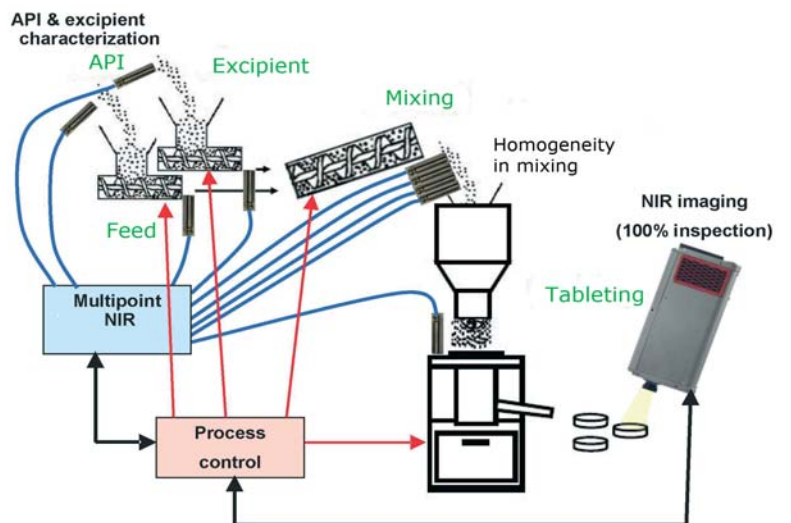
This approach is also beneficial in limited space application where there is no room for a lens imaging setup, or the imaging sensor must be totally non-magnetic, like in an NMR chamber.



Schematic of a matrix array to linear array fiber optical converter.



Multipoint display test station prototype
 Image: courtesy by Izuzu Optics, Taiwan



Pharmaceutical industry is starting to move from batch processes to continuous manufacture. Running a continuous process with constant quality requires to monitor chemical and physical parameters in the raw materials and various process phases in real time. A multiple-point NIR spectrometer provides a cost-efficient single instrument solution to monitor the incoming materials as well as the mixing phase in multiple positions in order to guarantee the homogeneity of the product.