Filtering advances widen spectroscopy options

Thanks to their ability to cover a wide spectral range, continuously variable order sorting filters have come to the fore in spectroscopy, finds Jessica Rowbury

Continuously variable filters (CVFs) are beneficial in spectrometers because they can be used in place of multiple fixed filters while achieving the same spectral performance.

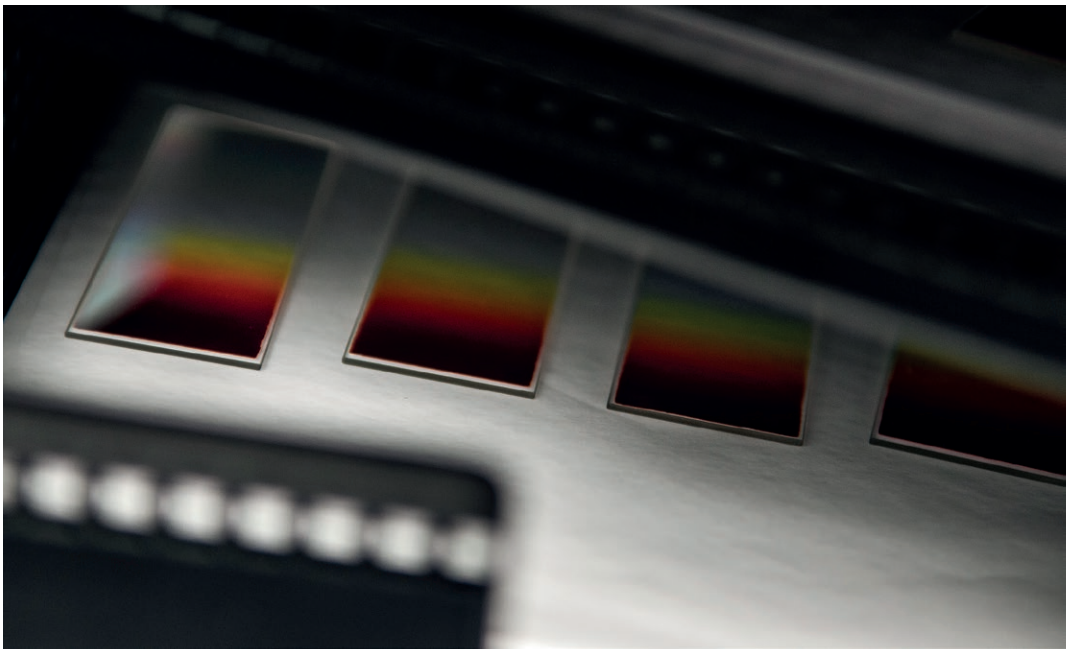
Despite having existed for many years, it is only recently that the spectral performance of CVFs has reached the required level for spectroscopy applications, which has been thanks to improvements in design and production technology.

Within spectrometers, the most relevant type in use today is an order sorting filter, which can cover a wide spectral range.

Thomas Rasmussen, VP for business development, sales and marketing at Ibsen Photonics, told *Electro Optics*: 'Any spectrometer that uses a diffraction grating and that covers more than one octave [ratio of upper to lower wavelength is larger than two] will require an order sorting filter.

'For spectrometers that cover less than one octave, it is possible to use a simple long wave pass filter with a fixed cut-on wavelength. But if you have a wider wavelength range you will always need a more complex order sorting filter,' he said.

For spectrometers that cover more than one octave, a second or third order sorting filter with a different cut-on wavelength is needed to cover the required spectral range. So, a typical spectrometer from 190nm to 1,100nm would need three different order sorting filters. This means there will always be a transition region where the detector will collect meaningless signals, which happens no matter if the three different filters are mechanically assembled or directly coated onto one substrate.


Delta Optical Thin Film

Rasmussen noted: 'When companies like Delta Optical Thin Film introduced their Continuously Variable Order Sorting Filters, they introduced a whole new and more advanced way of doing order sorting within spectrometers,' he said.

The spectral properties of Delta's CVFs vary continuously along one dimension of the filter. The coating thickness increases continuously and the cut-on wavelength changes continuously along it.

Thanks to this feature, a single CVF can replace a number of fixed filters in an instrument.

'If you have a very broad range – for example from 200 to 1,100nm – you have many different orders and they all fall in different ranges, so for different parts of the wavelength regions you need different filters, said Rasmussen. 'This is quite difficult in manufacturing [of spectrometers], because you would need one filter for one section – you might need to have a red filter in one area, and another colour such as green or blue in another area. The more detail you need, the more complicated it becomes.'

"These have been crucial for the development of Ibsen's spectrometers"

The filter performance is also improved with CVFs because there are no gaps in the measurements between the filters. Rasmussen pointed out that these features have been crucial for the development of Ibsen's spectrometers.

'For our Freedom product line of broadband spectrometers there is no way we could get them to work without this kind of continuously variable filter from Delta,' Rasmussen said. Ibsen's Freedom UV-VIS covers the 190 to 850nm wavelength range, and its Freedom UV-NIR 190 to 1,100nm.

'The only alternative would be to use step filters – in this case, we would have to ask somebody to coat certain sections of a glass plate with a certain filter. We would probably need two or three different regions with different filters,' he continued. 'But with this method there is no continuous linear function like you find in the Delta filters. In one area there would be one filter, and then a jump to the next area – meaning there would be a small part of the spectrum that is undefined'.

'The nice thing about Delta filters is that they make this continuous range, that goes through different ranges, and can work over a very wide range of wavelengths,' he said.

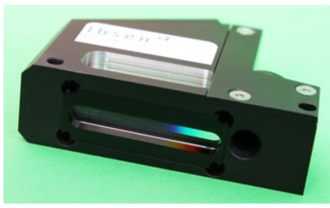
From the lab to the field

Traditionally, lab-based broadband spectrometers do not need order sorting filters as they only work on one wavelength at a time, said Rasmussen: 'We are talking about big machines that only really work in the lab – they are typically very expensive and have moving parts inside, so they are not really ruggedised for outdoor environments.'

For applications outside of the lab, where the whole spectrum of light is entering the detector at the same time, continuously variable order sorting filters are required to achieve the performance needed to filter out the undesired orders.

'In spectroscopy, you are always looking for peaks, and without order sorting you get these false peaks – basically peaks that are not supposed to be there, and you need to filter them out so you can only see the correct peaks,' said Rasmussen.

Before order sorting filters, the traditional solution would have been to utilise a piece of coloured glass that absorbs light as required by the particular application. For example, if you look through a piece of red glass it absorbs all light except the red wavelength.



Delta Optical Thin Film

Ibsen's spectrometer with sensor removed showing filter

A more high-end or advanced way to achieve the same effect would be to use a dielectric-coated filter, which consists of a series of multiple thin layers of dielectric materials deposited on top of the glass substrate. Rasmussen explained: 'This type of filter provides a more advanced option because the operator can determine which wavelengths he or she wants to block, and which ones should still be transmitted.'

However, these layers limit transmission, lifetime and laser-induced damage threshold.

Delta's CVFs suppress more stray light – which improves accuracy – because the cut-on wavelength moves together with the dispersion of the grating. With discrete filters the distance from the cut-on wavelength to the first order one wants to transmit gets gradually bigger and allows more stray light to pass through the filter.

Accuracy is highly important for avoiding false peaks. Rasmussen explained: 'A huge part of what we do is chromatography, and coating measurements, where you want to measure thickness and material properties of coatings and flat substrates in the semiconductor industry – this is also where you typically use broadband spectrometers.

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'It is important to eliminate the false peaks because there is no way to tell whether it is a true peak or a false peak when you look at the spectrum. Normally you don't know what you are looking for, so accuracy is important!'

Delta Optical Thin Film's Continuously Variable Order Sorting Filters are coated on UV grade fused silica substrates, and can be supplied with different dispersions matched to a specific detector and in different sizes. They can be manufactured either with a coating that covers the whole length of the filter or with a section that allows UV light to pass. **EO**