Superior ICP-OES optical design for unmatched speed and performance

Technical Overview

5110 ICP-OES

Introduction

The Agilent 5110 ICP-OES combines a vertical torch, unique dual view and synchronous dual view pre-optics, and state-of-the-art echelle optical design with innovative CCD detector technology. The efficient and highly optimized optical design in the 5110 ICP-OES incorporates Image Mapping (I-MAP) and Adaptive Integration Technology (AIT). This combination provides unique, true simultaneous measurement, full wavelength coverage, and enables unrivalled elemental analysis speed and performance — without the need for multiple detectors or multiple entrance slits.

Simultaneous ICP-OES

Simultaneous ICP-OES instruments incorporating solid-state detection systems, including charge-coupled device (CCD) and charge injection device (CID) detectors, have largely replaced traditional, sequentially-scanning ICP-OES instruments. Solid-state detectors used with ICP offer many advantages including:

- Faster analysis times, providing greater sample throughput and reduced cost of ownership.
- Improved data integrity, by allowing the determination of elements using multiple emission lines for data confirmation with no time penalty.
- Better accuracy and precision, achieved by reduced instrument drift and simultaneous internal standard and background correction.

Furthermore, CCD/CID technologies provide an opportunity for the development of powerful software features that greatly simplify operation, including the complete automation of instrument optimization, background correction, analyte measurement time and sample washout.

Most manufacturers of ICP-OES with solid-state detectors describe such systems as 'simultaneous'. Yet sample measurement times can vary greatly from one so-called 'simultaneous' instrument to another, and can vary depending on the number of wavelengths selected for measurement, and even due to the concentration/signal intensities of the selected wavelengths. This is often related to the different approaches taken by manufacturers in optical and detector design, and how the information captured by the detector is processed.

Only the Agilent 5110 ICP-OES instruments deliver true simultaneous measurement of the complete wavelength range, for best-in-class performance.

Superior optical design

Most modern simultaneous ICP-OES instruments use an echelle polychromator design to separate and focus analyte emission lines generated in the plasma onto the detector for measurement. The popularity of the echelle polychromator in ICP-OES grew with the introduction of solid-state detectors, as the compact two-dimensional optical image produced by the echelle optics complemented the X-Y grid array design of the detector. Optical emissions generated in the plasma are directed through the pre-optics to an entrance slit (or in some cases, directed through multiple entrance slits sequentially) and focused onto a diffraction grating. The various diffraction orders reflected from the grating are essentially superimposed and are dispersed using a prism, producing a two-dimensional echelle image.

The echelle polychromator used in the 5110 ICP-OES (Figure 7) is unique in that it produces a single echelle image that is projected onto a single detector, for superior analysis speed, precision and accuracy. There is no need for multiple detectors or entrance-slit optics to achieve full wavelength coverage that can reduce analytical performance and often require separate sequential measurements to be taken, increasing analysis times.

The excellent optical resolution of the 5110 (Figure 1 and Table 1) is achieved through the use of higher and optimized diffraction orders that are characteristic of the echelle optical design.

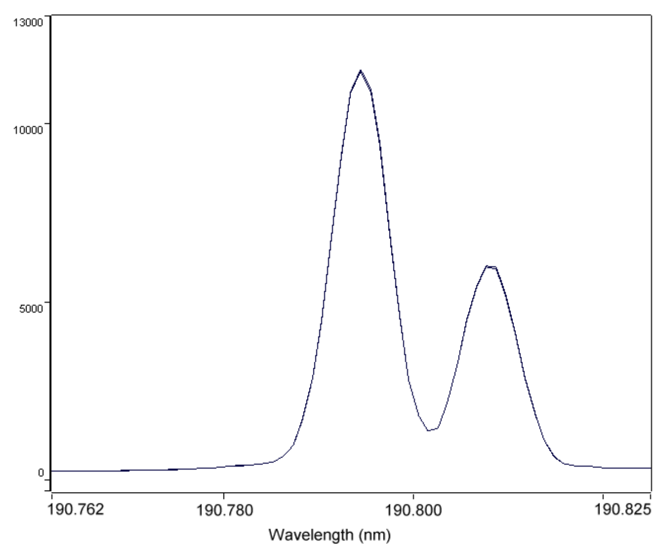

Figure 1. With the excellent optical resolution of the Agilent 5110 ICP-OES, the peaks of the thallium 190.794 nm and 190.807 nm doublet are easily identifiable

Table 1. Typical resolution performance of the Agilent 5110 ICP-OES (based on FWHM)

Element	Wavelength (nm)	Resolution (pm)
As	188.980	<7
Mo	202.032	<7
Zn	213.857	<7.5
Pb	220.353	<8
Cr	267.716	<9.5
Cu	327.395	<13
Ba	614.171	<34

Image Mapping Technology

The 5110 ICP-OES features a custom-designed and proprietary VistaChip II CCD detector (Figure 2). Utilizing Image Mapping Technology (I-MAP), only 70,000 light-sensitive pixels located on 70 diagonal linear arrays (DLAs) are required to cover the full wavelength range from 167 to 785 nm. The position and length of each DLA on the VistaChip II detector are aligned to match the free spectral range of each diffraction order produced by the echelle optics (Figure 3).

Figure 2. Custom-designed and proprietary CCD detector. With unique I-MAP and AIT, speed and versatility is unmatched, and full wavelength coverage is provided from 167–785 nm.

I-MAP eliminates the need for pixels between DLAs where no spectral information exists. The readout and related charge-transfer circuitry controlling the pixels are located between DLAs, allowing independent control.

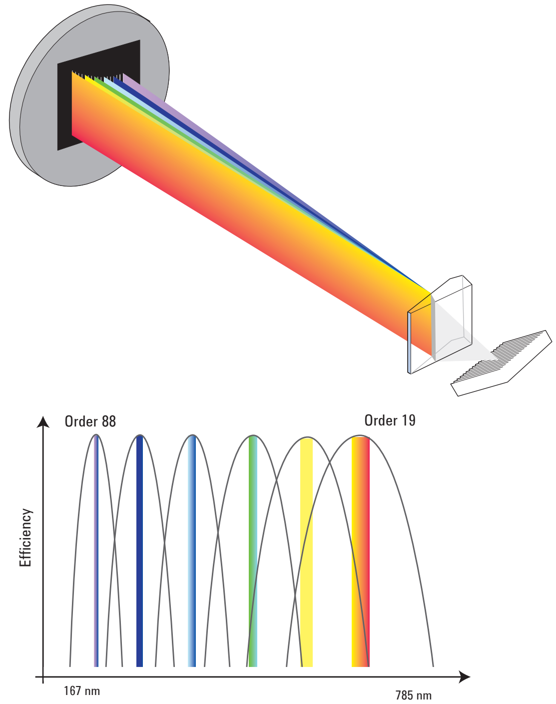

Figure 3. The layout of photosensitive pixels on the VistaChip II are arranged to exactly match the spectral free range of each diffraction order produced by the echelle optics

Adaptive Integration Technology

Adaptive Integration Technology (AIT) is an intelligent algorithm that prevents over-range signals by automatically adjusting the integration time for each emission line depending on the incoming signal intensity (Figure 4). AIT automatically sets the optimum integration time, allowing all element concentrations to be determined with a single, truly simultaneous measurement regardless of the analyte concentration or the sensitivity of the chosen emission line.

AIT is also ideal for collecting time-resolved data when combining chromatography or laser ablation techniques with ICP-OES.

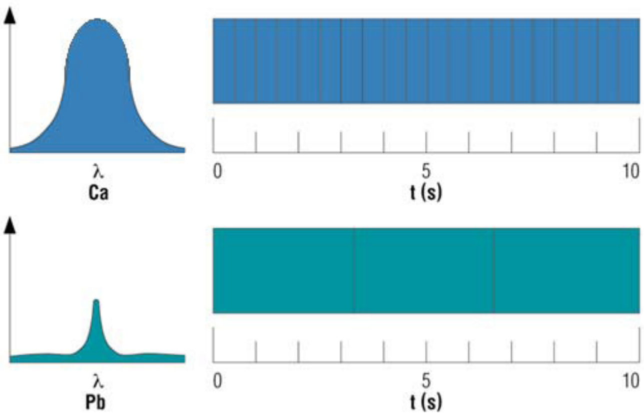

Figure 4. Using a 10 s replicate read time, AIT will average lots of short readings for high intensity signals and few, longer readings for low intensity signals, simultaneously providing the optimum signal-to-noise ratio.

Fast signal readout

With 1 MHz pixel processing speed, the VistaChip II detector sets the benchmark against which detector speed in ICP-OES is measured. Duplex circuitry enables pixels to be read out from both sides of the detector (Figure 5), ensuring a readout speed significantly faster than competitive systems. With the 5110 ICP-OES, you can measure the entire spectrum from 167 to 785 nm in less than one second.

Figure 5a shows a close-up of five DLAs on the VistaChip II CCD. Figure 5b shows the micro-electronic circuitry used to control the photosensitive pixels.

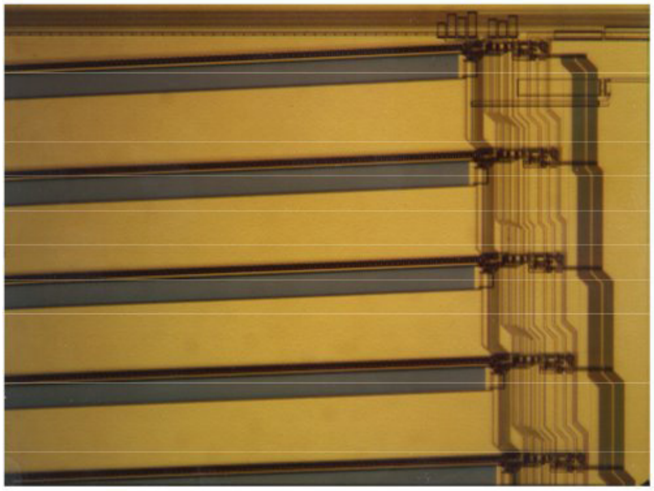

Figure 5a. Individual DLAs on one side of the VistaChip II CCD with associated readout circuitry

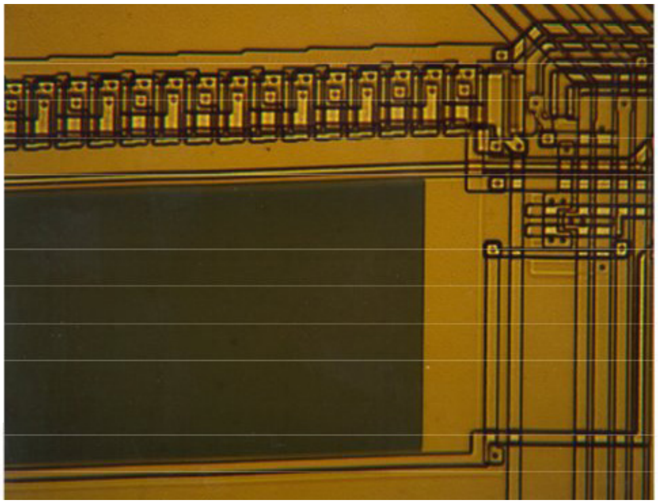

Figure 5b. A single DLA at higher magnification. The dark region is the photosensitive area. The anti-blooming drain can be seen running continuously along the bottom of the photosensitive area and the readout control circuitry for each pixel along the top.

Anti-blooming on every pixel

'Blooming' is an undesirable property of a solid-state detector, whereby intense illumination of one part of the detector can interfere with the measurement of nearby pixels. Unlike segmented CCD detectors, the VistaChip II CCD features anti-blooming protection on every pixel. If pixels are saturated by a very intense signal, the excess signal overflows into the anti-blooming drain (Figure 6), rather than neighboring pixels. This ensures trace elements can be accurately measured in the presence of high concentrations of other elements.

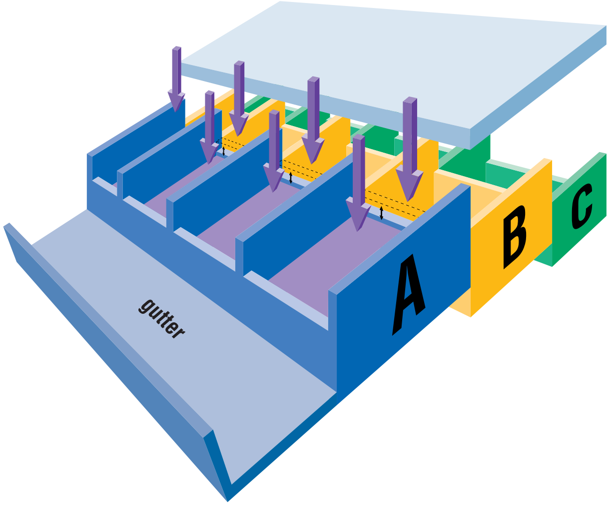

Figure 6. Schematic of a single DLA on the VistaChip II CCD illustrating the potential barriers between pixels and the anti-blooming drain

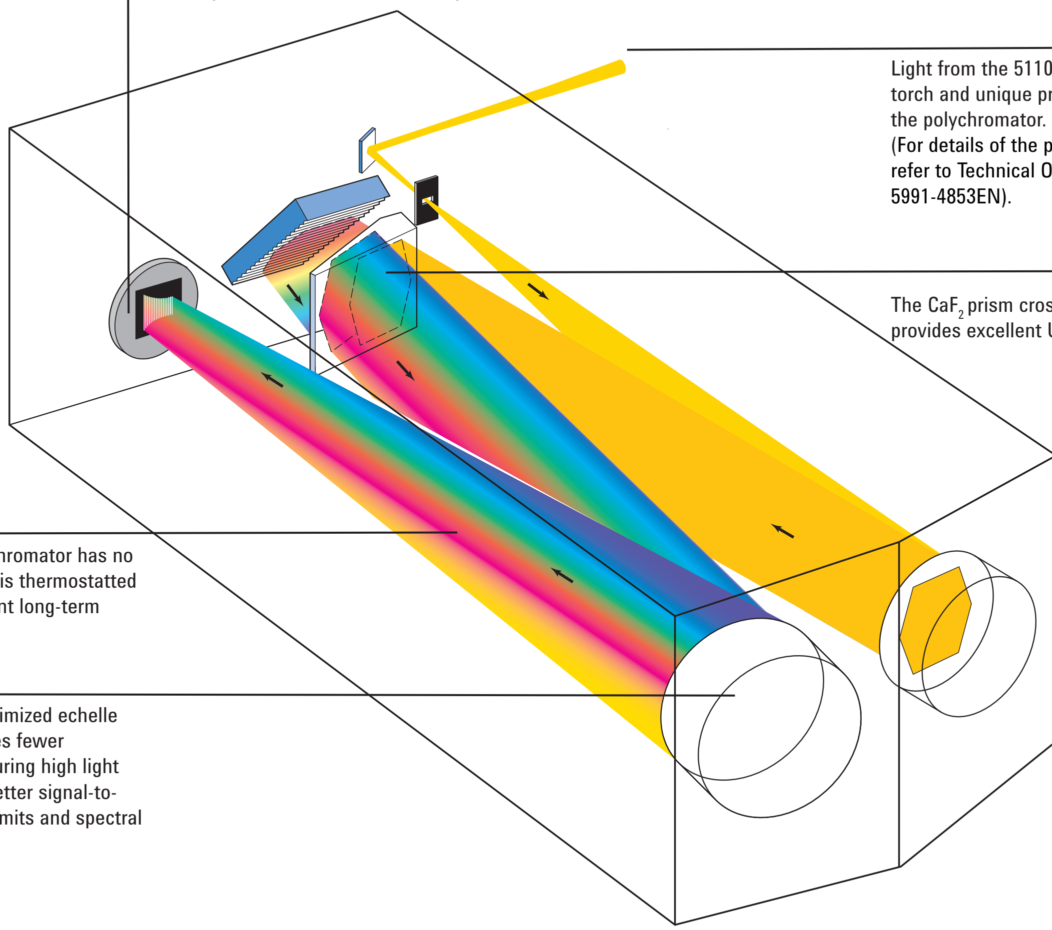

Figure 7. The Agilent 5110 ICP-OES computer-designed and optimized echelle optics uses fewer components providing high light throughput and superb stray light rejection performance for the lowest possible detection limits, even with complex sample matrices

Summary

Only the Agilent 5110 ICP-OES with the custom-designed VistaChip II provides true simultaneous measurement across the full wavelength from 167 to 785 nm for unmatched speed and performance. Now hermetically-sealed and cooled to -40°C, the next generation VistaChip II requires no gas purging or startup delay, saving you even more time and money.

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