

Advanced Optical Components for Analytical and Life Sciences Instrumentation



Introduction

The analytical and life sciences industry rely heavily on optical instrumentation to detect, quantify, and analyze complex biological and chemical systems. The demand for higher resolution, sensitivity, and compactness in these instruments necessitates the use of specialized optical components:

- **Aspheric mirrors** enhance optical precision while minimizing size and aberration.
- **Diffraction gratings** offer spectral dispersion critical for techniques such as spectroscopy.
- **Hollow retroreflectors** ensure precise beam return and alignment, especially in laser-based systems.

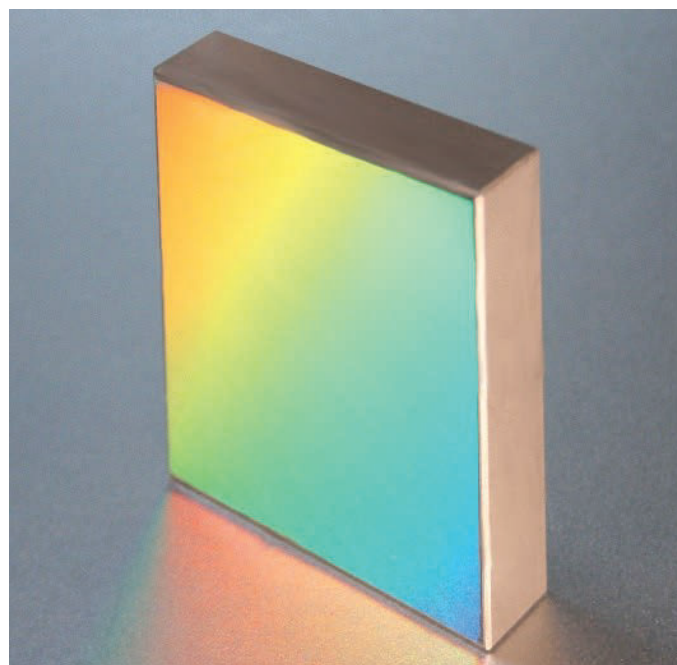
Understanding how these components function and where they are applied can help researchers and engineers design better instruments that meet evolving scientific needs.

Aspheric Mirrors

Aspheric mirrors, characterized by their non-spherical surface profiles, offer significant optical advantages over traditional spherical optics.

Their ability to correct for aberrations and focus light with high precision makes them ideal for compact, high-performance optical systems.

In analytical and life science instrumentation, aspheric mirrors are instrumental in improving resolution, throughput, and overall system efficiency.



Blazed Holographic Grating

Applications in Analytical Instrumentation

Analytical instruments such as spectrometers, optical coherence tomography (OCT) systems, and laser-induced breakdown spectroscopy (LIBS) devices increasingly rely on aspheric mirrors for beam shaping, collimation, and focusing.

Unlike spherical optics, aspheric mirrors can correct for spherical aberrations without the need for multiple optical elements, enabling more compact and cost-effective designs. This is particularly beneficial in portable or miniaturized instruments where space and precision are critical.

Aspheric Mirrors cont...

Impact on Life Sciences

In the life sciences, where accurate optical imaging and detection are essential, aspheric mirrors enhance the performance of techniques such as fluorescence microscopy, flow cytometry, and optical biosensors.

Aspheric mirrors also improve signal collection efficiency and reduce stray light, resulting in higher signal-to-noise ratios and more precise data. For example, in fluorescence imaging, aspheric mirrors help achieve sharp, distortion-free images critical for analyzing cellular structures or molecular interactions.

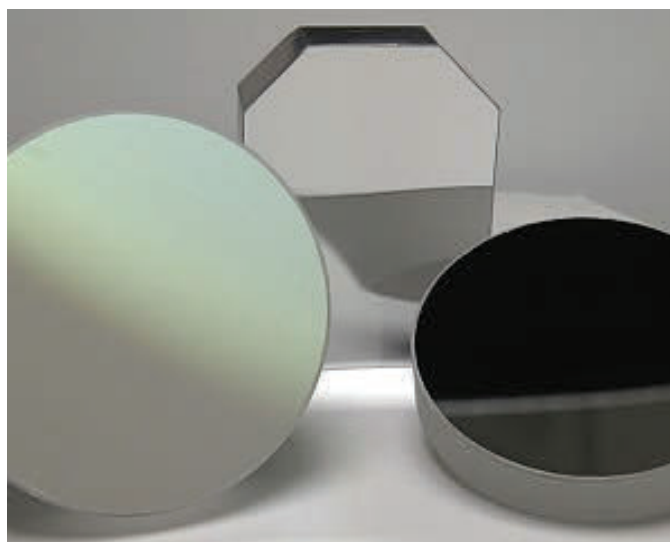
Advantages

Aberration Correction: Aspheric mirrors reduce or eliminate spherical aberrations, improving image quality and measurement accuracy.

Compact System Design: By minimizing the number of required optical elements, aspheric mirrors support lightweight and space-saving instrumentation.

Enhanced Light Throughput: Efficient focusing and collimation boost signal strength and sensitivity - crucial for detecting low-intensity biological or chemical signals.

Aspheric mirrors are transforming the design and performance of optical systems in analytical and life science instrumentation.



Aspheric Mirrors

Their precision, efficiency, and versatility enable scientists and engineers to build more accurate, compact, and reliable tools for diagnostics, research, and process monitoring. As innovation in optics continues to accelerate, the adoption of aspheric mirrors will remain central to the development of next-generation scientific instrumentation.

Spectrum Scientific offers a wide range of aspheric mirrors, including:

- **Off-axis parabolic mirrors**
- **Elliptical mirrors**
- **Freeform mirrors**

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Diffraction Gratings

Diffraction gratings are optical components that disperse light into its constituent wavelengths by means of interference. These precision-engineered surfaces, etched or replicated with periodic structures, are fundamental to a wide range of optical systems. In analytical instrumentation and life sciences, diffraction gratings are indispensable for enabling high-resolution, wavelength-specific detection critical for diagnostics, research, and quality control.

Applications in Analytical Instrumentation

Analytical instruments such as spectrophotometers, monochromators, and optical spectrum analyzers rely heavily on diffraction gratings for wavelength discrimination.

By separating polychromatic light into individual wavelengths, gratings enable accurate qualitative and quantitative analysis of chemical compositions. High-efficiency transmission and reflection gratings are used in UV, visible, and infrared spectrometers to analyze substances in fields such as environmental testing, food safety, and pharmaceuticals.

Impact on Life Sciences

In life sciences, diffraction gratings support a broad range of applications, including genomics, proteomics, and drug discovery. Instruments like DNA sequencers and fluorescence-based microplate readers use gratings to differentiate fluorescent signals from various dyes, improving the sensitivity and specificity of assays. Moreover, high-throughput screening systems in biotechnology and molecular biology depend on

the performance of gratings to ensure reliable and reproducible results across large sample volumes.

Key Advantages

High Spectral Resolution: Gratings provide superior spectral resolution compared to filters or prisms, critical for detecting closely spaced wavelengths.

Wavelength Versatility: They operate across a wide spectral range (UV to IR), making them adaptable to multiple applications.

Customization: Diffraction gratings can be optimized for blaze angle, groove density, and coating to match specific application requirements.

Diffraction gratings play a pivotal role in enhancing the performance of analytical and life science instrumentation. Their ability to precisely manage and analyze light enables breakthroughs in research, diagnostics, and industrial applications. As demand grows for more compact, sensitive, and high-throughput systems, the role of diffraction gratings will continue to expand, driving innovation across scientific and medical fields.

Spectrum Scientific offers a wide range of diffraction gratings, including:

- **UV blazed holographic gratings**
- **Ruled gratings**
- **Plane, concave or convex gratings**
- **Aberration corrected, flat field imaging gratings**

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Monolithic Hollow Retroreflectors

Hollow retroreflectors are precision optical components having three mutually orthogonal mirror surfaces. They reflect an incoming beam back exactly along its original path, regardless of incident angle. Monolithic retroreflectors offer a number of advantages over traditional retroreflectors, including their ability to maintain a constant angle of reflection and their lack of joints or seams.

Advantages

High Beam Return Accuracy: Better than 2 arcsec. Ideal for interferometry and alignment applications.

Thermal and Mechanical Stability: No optical path distortion due to solid materials.

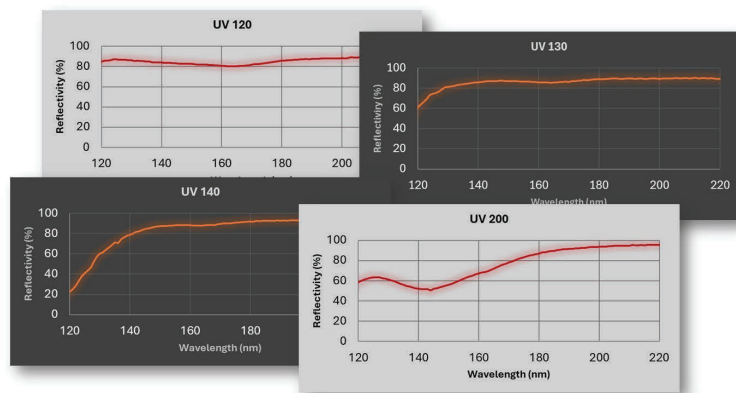
Solid Construction: insensitive to vibration, position and movement.

Incorporation of Fiducials on the Retroreflector itself: easy alignment giving additional design and cost benefits.



Monolithic Hollow Retroreflectors

Optical Coatings



VUV and DUV Coatings from 120-280nm

Our products can be supplied with a number of different coating options.

For UV, visible, and infrared applications, aluminum coatings are generally used as they are more resistant to oxidation when compared to silver and offer better UV performance.

Aluminum averages greater than 90% reflectance from 200nm to the far infrared, except in the 750 – 900nm region where it averages around 85% reflectance.

For IR performance gold coatings offer high reflectivity of around 97% from 700nm up to 10 μ m.

We also offer a range of ultra-high reflectivity DUV and VUV coatings down to 120nm which deliver up to 10% higher reflectivity compared to standard UV coatings, making them ideal for manufacturers of analytical and life science instruments.

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About Spectrum Scientific

Spectrum Scientific, Inc (SSI) has been manufacturing high volume flat, aspheric and freeform reflective optics, hollow retroreflectors and holographic diffraction gratings since 2004.

We primarily use the optical replication process allowing us to supply high fidelity, high specification precision optics at a lower cost compared to traditional volume manufacturing.

One of our key capabilities is the manufacture of freeform optics, off-axis paraboloids and ellipsoid mirrors with surface figures down to $\lambda/10$ or better. We also manufacture plane, concave and convex holographic diffraction gratings, which can be supplied as blazed gratings using our proprietary blazing technique, which not only offers high efficiency in the UV, but lower stray light compared to conventional ion etched gratings.



Spectrum Scientific is ISO 9001:2015 certified and RoHS compliant and our production and test areas are space qualified

WP - OFAI250619

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