From Life Sciences to Industry: Advancements in Optical Filters

Emerging applications and technology trends in optics

Abstract:

Optical filters are essential components in a wide range of applications, from life sciences and industrial inspection to environmental monitoring and consumer electronics.

Chroma Technology, a leading manufacturer in this field, has more than 30 years of expertise in creating a wide range of both standard and highly customized optical filters. This white paper explores the technical advancements and capabilities of Chroma Technology's filters, highlighting their applications and the company's approach to custom solutions.

Introduction to Optical Filters

Optical filters are indispensable components in a wide range of modern optical technologies, playing a crucial role in various scientific, medical, consumer and industrial applications. These devices are designed to selectively transmit, reflect, or block specific wavelengths of light, enabling precise spectral control over. As technology advances, the potential of optical filters continues to grow, particularly in some exciting new and emerging applications such as augmented and virtual reality, advanced medical imaging, environmental monitoring, and satellite communications.

Applications of Optical Filters in Modern Technology

In the medical imaging industry, optical filters are integral to techniques such as fluorescence microscopy and optical coherence tomography (OCT). These filters enhance the ability to distinguish between different types of tissues and provide detailed images of biological structures.

Environmental monitoring benefits from optical filters in devices that detect pollutants or analyze atmospheric conditions. These filters allow scientists to isolate specific wavelengths of light, enabling the accurate identification of chemical compounds in the environment. This capability is essential for tracking climate change, monitoring air quality, and managing natural resources.

In free-space laser optical communications, optical filters are vital for data transmission from ground-air, air-air, and even over satellite networks. The filters ensure that signals maintain spectral integrity, reducing noise, enabling faster and more reliable communication. As the demand for high-speed internet and data services grows, the role of optical filters in supporting these infrastructures becomes increasingly significant.

Advancements in laser technology also highlight the importance of optical filters, particularly in applications involving ultrafast pulsed lasers. These lasers, with pulses in the femtosecond to picosecond range, are used in precision machining, medical procedures, and scientific research.

Types of Optical Filters

Multiband Filters

Multiband filters from Chroma Technology are designed to transmit multiple wavelengths simultaneously while blocking others. These filters are crucial in applications requiring high-speed acquisitions, such as fluorescence microscopy, machine vision, and semiconductor inspection.

Technical Specifications and Applications

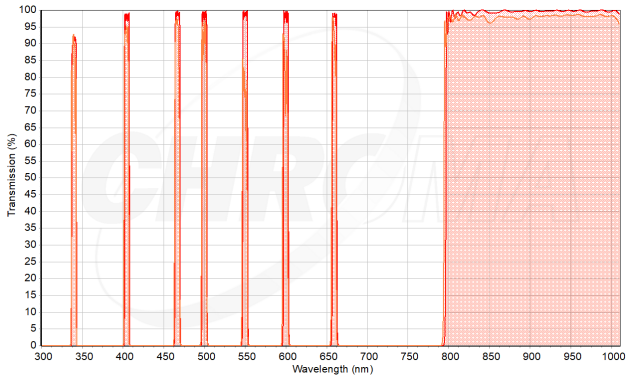
Wavelength range: Multiband filters can have a number of distinct bands, with bands ranging from the UV to SWIR all in the same filter - the possibilities are almost limitless.

Numbers of bands and bandwidth variation: Chroma Technology has routinely made filters with four and five bands, and has also demonstrated the ability to make multibands with seven distinct bands.

OD (optical density) performance: Capable of achieving OD6 between passbands, ensuring minimal crosstalk and high precision.

Use Case

A life sciences application required a multiband filter with 7 narrow bands from UV to VIS, plus a long-pass for NIR light) for sequential laser excitation, where speed was paramount. Traditional filter wheels were too slow for the millisecond switching times needed. Chroma's multiband filter provided a static solution, enabling rapid sequential acquisition without moving parts.

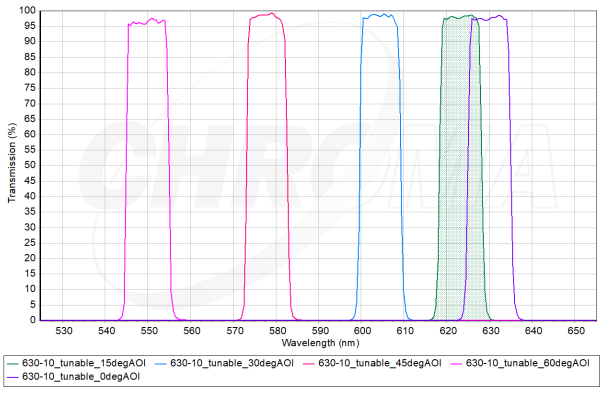


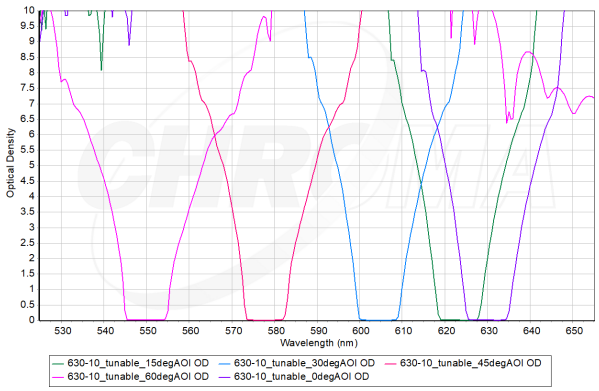
Tunable Filters

Tunable filters from Chroma allow users to dynamically adjust the transmission band by altering the angle of incidence. These filters are valuable in spectroscopy and multispectral imaging, where flexibility and precision are necessary.

Technical Specifications and Applications

Angle of incidence adjustment: Chroma's tunable filters work by adjusting the angle of incidence which causes the passband to shift. A 10nm wide tunable bandpass filter, for example, could have a 0deg AOI centre-wavelength at 630nm, and shift down to a centre-wavelength of 550nm at 60deg AOI, all while maintaining the 10nm bandwidth, and providing high transmission, and excellent near-band / out-of band blocking:





Wavelength range: Can cover UV to SWIR wavelengths with a single set of filters.

Precision: Requires precise angle control for accurate wavelength tuning.

Use Case

A customer developed a broadband light source and used Chroma's tunable filters to offer customisable wavelengths for different applications. This setup allowed the customer to cover a wide spectral range with fewer filters, significantly reducing costs and complexity.

Tristimulus Filters

Chroma's tristimulus filters are essential for accurate color measurement in display technology. These filters are designed to match the CIE color matching functions, which are critical for calibrating and verifying color accuracy in consumer electronics.

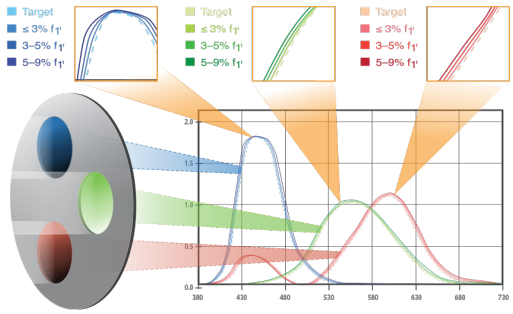
Technical Specifications and Applications

Low f1 prime score: Achieves less than 1% deviation from the CIE standard, ensuring high accuracy.

Field of view considerations: Customisable to match specific cone angles in various systems.

Use Case

In the display manufacturing industry, these filters help ensure that color reproduction on screens meets the highest standards. The precise match to CIE functions reduces noise and enhances the reliability of color measurements, contributing to consistent quality across devices.



Mid-wave Infrared (MWIR) Filters

Chroma's entry into the SWIR and now MWIR range expanded the company's capabilities into new domains, including remote sensing and gas analysis. These filters offer superior transmission, steeper slopes, and deeper blocking compared to many competitors.

Technical Specifications and Applications

Wavelength range: 3 to 6 microns.

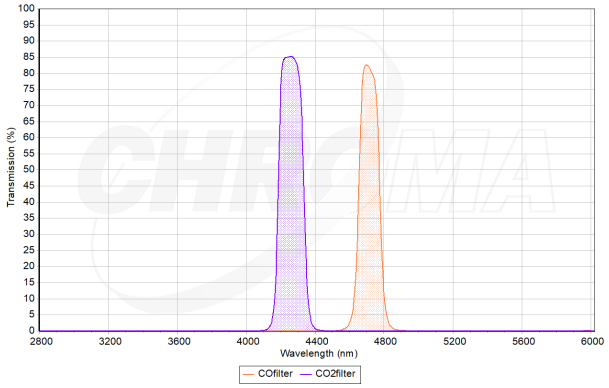
Material adaptation: Use of silicon or sapphire substrates for better performance in MWIR.

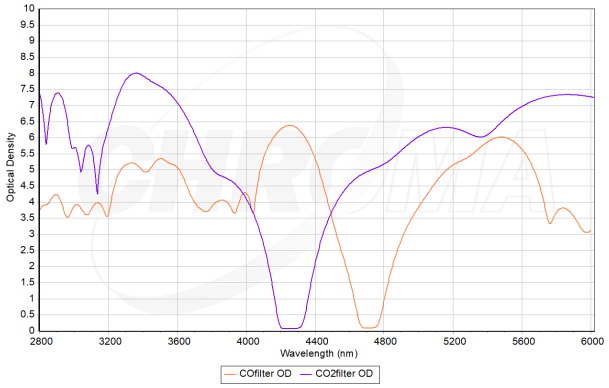
High transmission and blocking: Enables more precise gas detection and remote sensing applications.

Use Case

For environmental monitoring, Chroma's MWIR filters provide a better distinction between similar gases, such as CO and CO2. This precision is

crucial for applications such as Earth observation from satellites, where accurate gas differentiation can impact climate studies and pollution tracking.





Custom Solutions

One of Chroma's strengths lies in its ability to provide custom solutions tailored to specific customer needs. The company leverages its expertise in thin-film coating and precision engineering to develop filters that meet unique requirements, whether it's for a specific wavelength, angle of incidence, or application environment.

So, if you're looking for something a bit different, or you aren't sure what might best work for your particular application, the expert team at Chroma is here to help. Simply get in touch and let the team know what you are looking to achieve, and if the existing range of products don't quite fit, they will take you through the process of creating something custom that will work. Chroma is here to solve your light problems!

Technological Edge

Sputter coating process: This enables precise deposition for highly accurate filter performance.

Broadband monitoring: Ensures consistent quality across the manufacturing process.

Customer collaboration: Chroma's approach involves close collaboration with customers to understand their challenges and deliver solutions that enhance their applications. This customer-centric focus has led to innovations that set Chroma apart in the optical filter industry.

Chroma Technology's advancements in optical filter design and manufacturing underscore the company's commitment to quality and innovation. Whether it's multiband, tunable, tristimulus, MWIR, or any other type of optical filter, Chroma can provide a solution to meet the rigorous and specific demands of modern applications.

Get in touch with the team at Chroma today to get a head start on your application without delay.

“If you want to find the secrets of the Universe, think in terms of energy, frequency and vibration.”

— Nikola Tesla

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