Sapphire Advantages: Summary

Since their launch in 2001 Sapphire™ lasers have experienced unmatched market acceptance with more than 30,000 installations worldwide. The Sapphire family now includes three different series:

- **Sapphire LP free space lasers**
- **Sapphire SF ultra-narrow linewidth lasers**
- **Sapphire FP fiber-pigtailed lasers.**

Independent of the series, wavelength and power class, all Sapphire products come with the same unmatched combination of advantages encompassing performance, reliability, and ease of installation.

Summary of Advantages

- Wavelength scalability
- Power scalability
- Low noise output
- Ease of installation
- Unit to unit consistency

Advantage #1: Wavelength Scaling. Unlike some alternative technologies, Sapphire™ lasers can be designed to operate at any wavelength over a wide visible range.
Benefit: Sapphire lasers offer a choice of all legacy wavelengths, such as the ion laser lines at 488 nm, 568 nm and 594 nm, and the DPSS wavelengths 532 nm and 561 nm, as well as customized wavelengths such as 552 nm and 588 nm.
How? OPSLs use a tailor-made gain material.

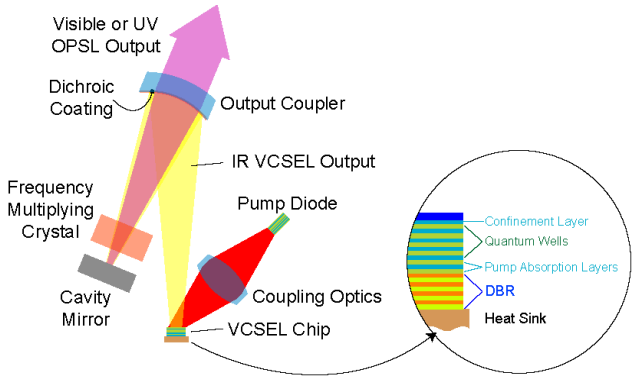

Figure 1. *Sapphire lasers utilize optically pumped semiconductor technology to produce near infrared laser light that is converted to visible output by intracavity frequency doubling.*

Sapphire lasers are based on Optically Pumped Semiconductor Laser (OPSL) technology. Here, a diode laser pumps a semiconductor chip whose emission wavelength is determined by the stoichiometry and physical dimensions of its quantum well structures. The chip can be fabricated to produce peak output anywhere from 700 nm to 1200 nm. Intracavity frequency doubling efficiently extends this to most of the visible spectrum (350 nm to 600 nm). Sapphire's technology can provide any wavelength in these ranges for any life sciences, metrology or inspection application. An example is confocal microscopy where Sapphire laser wavelengths optimally excite a growing range of flourophores. For more details about wavelength scaling, see

Sapphire Advantage Note #1
"Wavelength Flexibility"

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Advantage #2: Power Scaling. Unlike alternative technologies such as direct diodes, OPSLs can be easily scaled to higher power levels without affecting beam quality. Plus the output of any Sapphire laser can be adjusted from 10% to 110% of nominal power.
Benefit: With up to 500 mW of laser output, power-dependent applications can be run at higher signal-to-noise levels, producing better quality data and/or shorter data acquisition/procedure times. Conversely, lower power Sapphire lasers provide economical solutions for applications that are less power dependent.
How? OPSL architecture supports increased pumping power levels.

The simplified pumping geometry of the OPSL cavity enables its maximum output power to be raised simply by increasing the pump diode power. For the compact Sapphire LP models, these are available with powers up to 300 mW. Output powers of up to 500 mW can be reached with slightly larger Sapphire HP models. Plus the thin (10 µm) gain chip is effectively cooled from its rear surface and does not create a thermal lens. Together, this enables the power of any Sapphire laser to be smoothly adjusted over a wide range (e.g. 10% to 110% of nominal power) with no effect on beam pointing or transverse mode structure. Power flexibility means there is an optimum Sapphire laser power class for every application, and that in operation, the power can be smoothly adjusted as necessary, e.g. to low level for system alignment. For more details about power scaling, see

Sapphire Advantage Note #2
"Power Scaling"

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Advantage #3: Low Output Noise. Sapphire lasers are characterized by low output noise.
Benefit: Improved signal-to-noise ratios in most applications provide faster data acquisition and/or superior data quality.
How? OPSLs do not suffer from the "green noise problem" present in many DPSS lasers.

In other intracavity doubled solid-state lasers (e.g. DPSS), a noise-generating phenomenon called the "green problem" causes chaotic mode dynamic fluctuations which limit the ability of such lasers to produce low noise output. The only rigorous solution to this problem is single and stabilized longitudinal mode operation. However, this is too costly and complex for most CW visible applications, particularly for OEMs. But in OPSLs like the Sapphire, the near-zero upper state lifetime of the semiconductor gain chip completely eliminates the green problem and enables low-noise operation. Therewith, Sapphire lasers safely and cost-effectively improve the signal-to-noise in virtually any application. Examples include shorter data acquisition times in high throughput applications such as flow cytometry, and better data quality in imaging applications such as confocal microscopy. For more details about low noise output, see

Sapphire Advantage Note #3
"Low Noise"

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Advantage #4: Ease of Installation. Sapphire combines inherent OPSL advantages, including small size, low power consumption and low thermal demands, with value-added features such as multiple (analog, serial and USB) control interfaces. Plus all Sapphire LP models provide identical form, fit and function independent of wavelength and power class, as well as very high unit-to-unit consistency.
Benefit: Sapphire lasers use less space and impose lower power and thermal demands on OEM instruments and end-user applications alike. Their flexible control options make them simpler to integrate and operate.
How? Small solid-state components, simple PermAlign mounting, and folded cavity design.

Sapphire's active and passive components (see Figure 1) are completely solid-state, delivering the advantages of small size, high efficiency, consistent volume fabrication, and long-term reliability.

The relaxed geometric tolerances for pumping (see Sapphire Advantage Note #2 "Power Scaling") allows for a very compact laser cavity and pump arrangement. The optical components are aligned to optimum positions and then permanently held in position by Coherent's patented PermAlign method without the need of conventional bulky mechanical holders.

Furthermore a folded cavity incorporating optics to uncouple mode diameter and cavity length is used, as described in Advantage Note #2. As a result, a Sapphire LP laser head measures only 125 mm x 70 mm x 34 mm (4.9 in x 2.8 in x 1.3 in) and a 500 mW Sapphire HP laser head only 215 mm x 140 mm x 51 mm (8.4 in x 5.5 in x 2.0 in). In addition, its high electrical and optical efficiency means that Sapphire lasers are characterized by low power requirements and minimal waste heat. Since this thermal output must be dissipated in most applications, this reduces the overall thermal load for the instrument or system.

The Sapphire controller is also unique in providing three interfaces as standard – analog, USB and RS 232. This enables sophisticated, remote, two-way control including multi-faceted laser operational diagnostics. Sapphire lasers can also be operated in an autostart mode, where the laser is then simply switched on/off by powering/de-powering.

Another factor enhancing ease of installation is that all Sapphire LP models provide the same form, fit and function regardless of their wavelength or output power. This includes mechanical features (dimensions, weight, connector types/geometries) and identical optical parameters (xy beam position and beam angle at laser head exit, waist position, divergence). This advantage is beneficial for both OEMs and end-users who want to switch wavelengths or upgrade power class, or who want to integrate an additional wavelength into an existing Sapphire application.

Ease of installation is also enhanced by the exceptionally low unit-to-unit variation characteristic of Sapphire lasers. OPSL resonators have relaxed alignment requirements, particularly for pumping geometry, compared to other solid-state lasers - see Sapphire Advantage Note #2 “Power Scaling”. Moreover, Coherent’s PermAlign technology for aligning and fixing optical components through a soldering process allows for semi-automatic manufacture of the laser resonator using component pick-and-place techniques analogous to those long-used in the electronics industry. The precision and stability of this alignment and manufacture process, together with eliminating human operator subjectivity in production, yield superior unit-to-unit consistency. This can be highly beneficial, for example, in a flow cytometer where field-replacement of a laser head is relatively simple and does not require cumbersome and intensive re-alignment of the beam within the instrument. For more details about ease of integration, see

Sapphire Advantage Note #4
“Ease of Installation”

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Summary

Sapphire lasers leverage OPSL technology to deliver an unmatched combination of advantages amongst visible laser technologies. These include power and wavelength scalability, high quality output, ease of integration, superior reliability and exceptional consistency. For these reasons, Sapphire lasers have enjoyed tremendous success with system builders, particularly in life sciences and instrumentation applications. In fact, there are now over 30,000 Sapphire lasers in the field at 488 nm alone.