

Single-Stage Fiber Amplifiers Achieving Linewidths at the Tens-of-kHz Scale for Quantum and Semiconductor Applications

HÜBNER Photonics



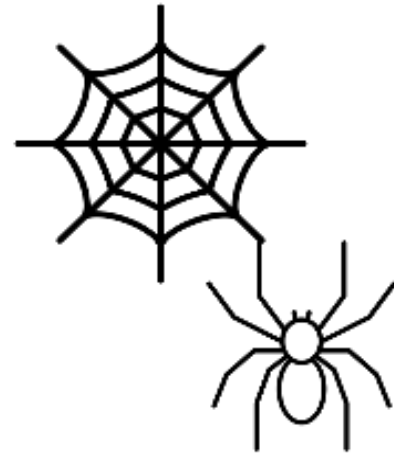
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Technology

The Ampheia™ Series is a family of high-power fiber laser systems, delivering ultra-low relative intensity noise (RIN) and single-frequency operation with up to 50 W of power at 1064 nm and 5W at 532 nm in a perfect beam. The Ampheia™ laser systems consist of a high performance fiber amplifier with an integrated single-frequency diode-pumped solid-state (DPSS) laser as a seed and a beam delivery head with beam shaping optics, frequency conversion and power detection for active power control. Integration of a high power DPSS ring cavity laser as a seed enables single-stage amplification, which reduces size and cost of the system. Use of this hermetically sealed and thermo-mechanically stabilized seed also provides many performance-related benefits, including < 100 kHz spectral linewidths, low intensity noise without active noise cancellation, and high optical signal-to-noise ratio (OSNR). This robust fiber amplified laser system also comes with a detachable laser head, easily facilitating integration of the system with OEM instrumentation and other laser systems.

Applications

- Quantum:** The high power and narrow linewidth of the Ampheia™ laser systems make them suitable for trapping of neutral atoms. Tightly focused interfering laser beams impose dipole forces on atoms which trap them in 1-, 2- or 3-dimensional arrays (optical lattices). Trapped ultra-cool atoms can be used to make optical atom clocks for extremely precise time measurements or to create qubits for quantum computing.
- Semiconductor manufacturing:** Advanced semiconductor chip manufacturing requires an environment with little-to-no particle contaminants and relies on tools like particle counters and analyzers to monitor the ambient environment. With high power, low noise, and high reliability, the Ampheia™ laser systems are top candidates for use in such counters, where low detection levels and high up-times are paramount.
- Laser pumping:** Performance characteristics such as narrow linewidth, high frequency and pointing stability, and excellent beam shape and OSNR make the Ampheia™ laser systems ideal for pumping Ti:Sa lasers, OPOs, or OPAs.



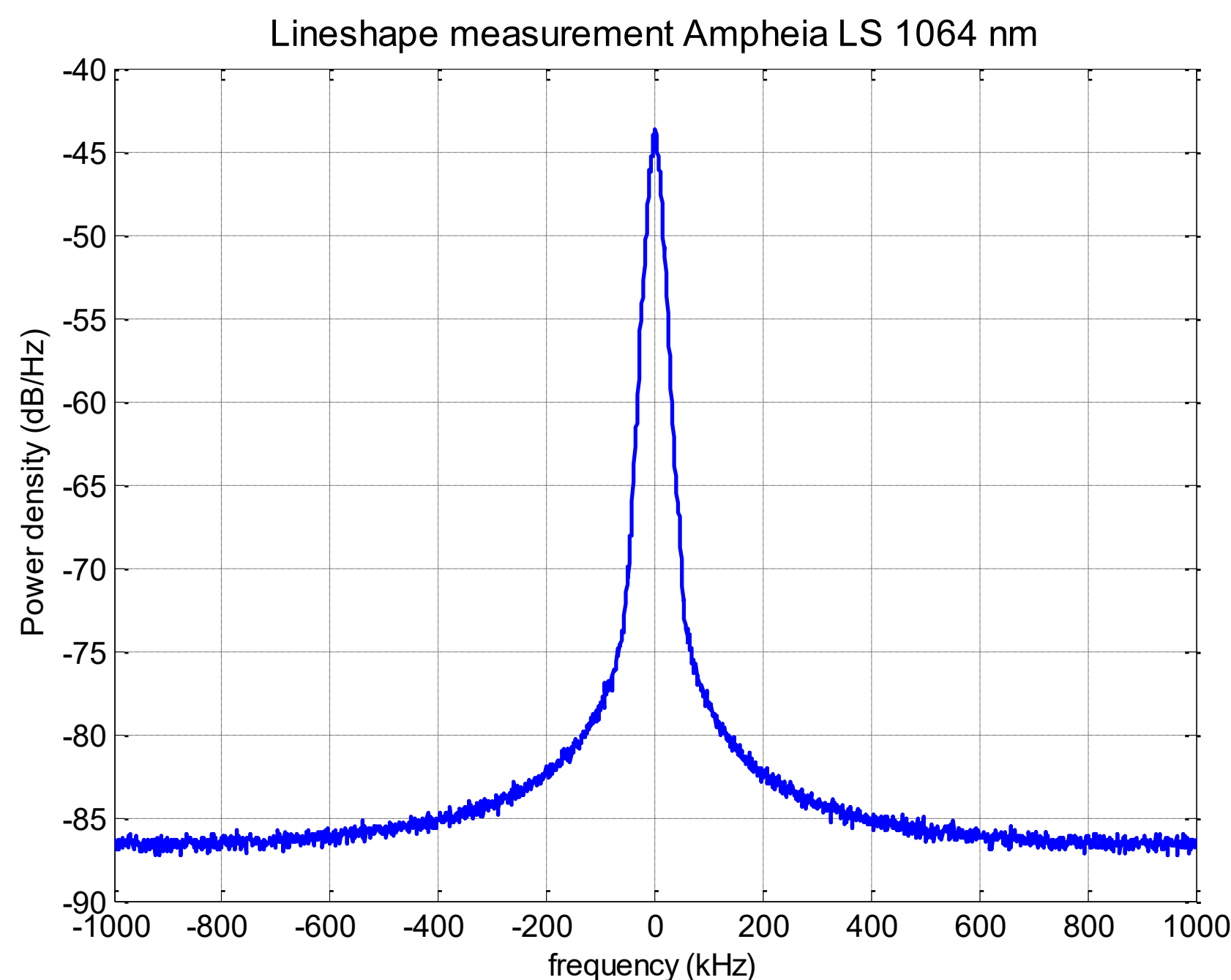
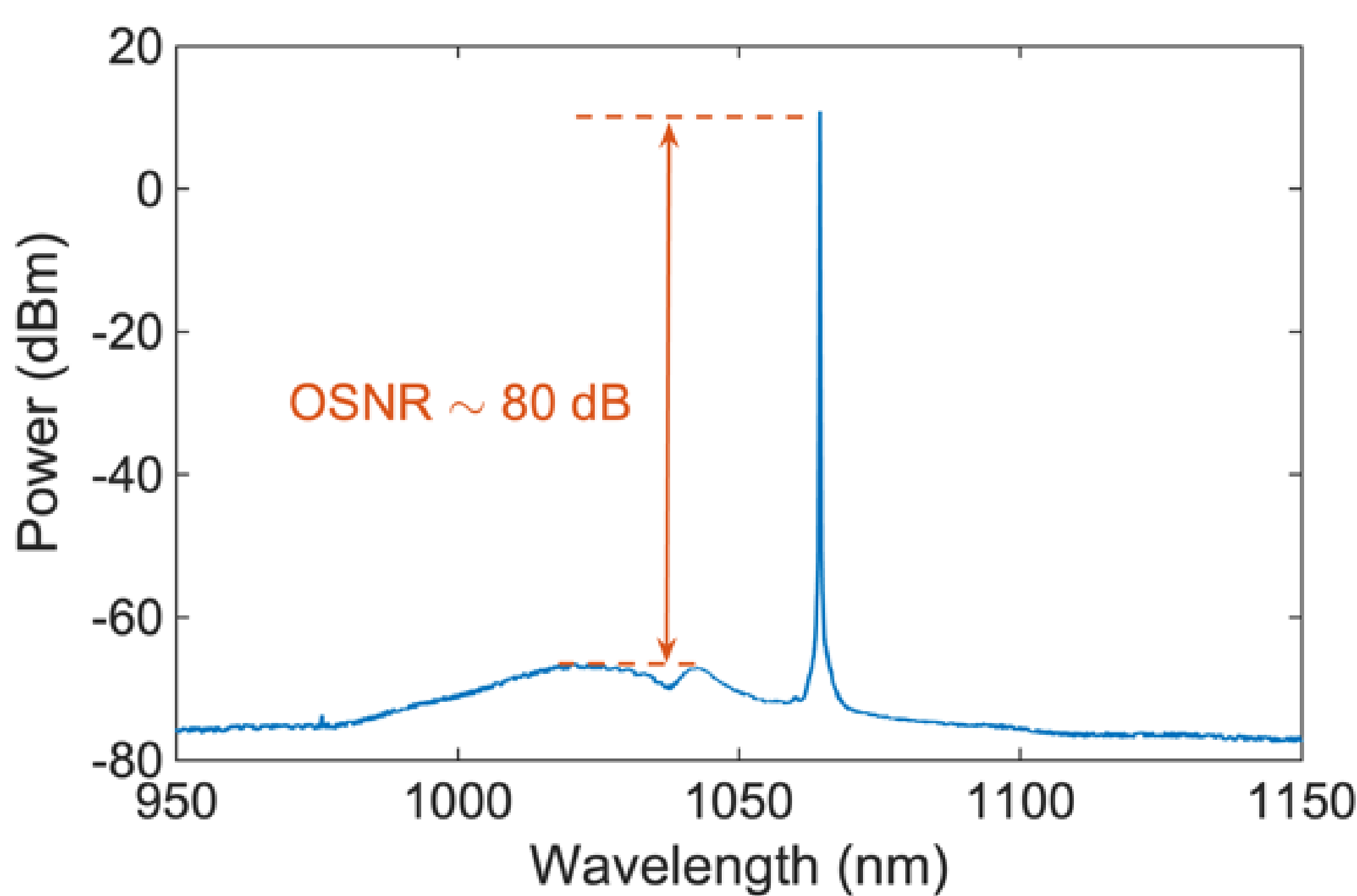
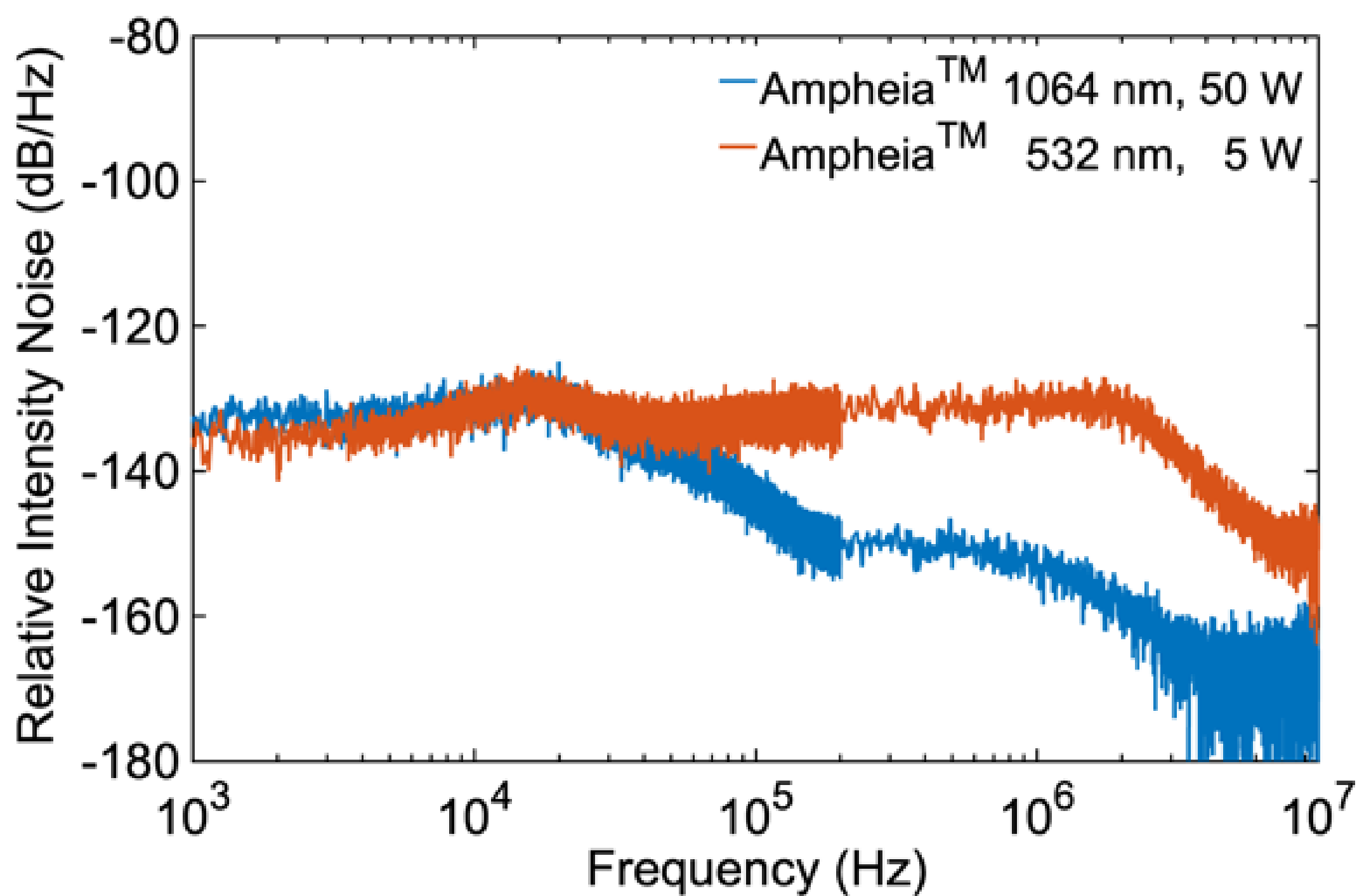
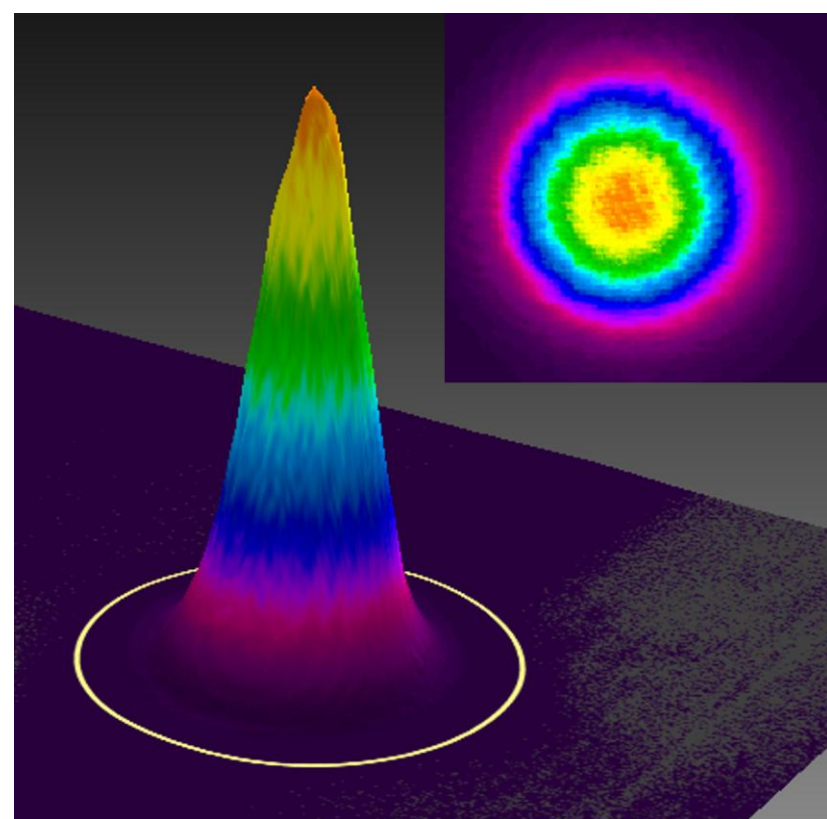
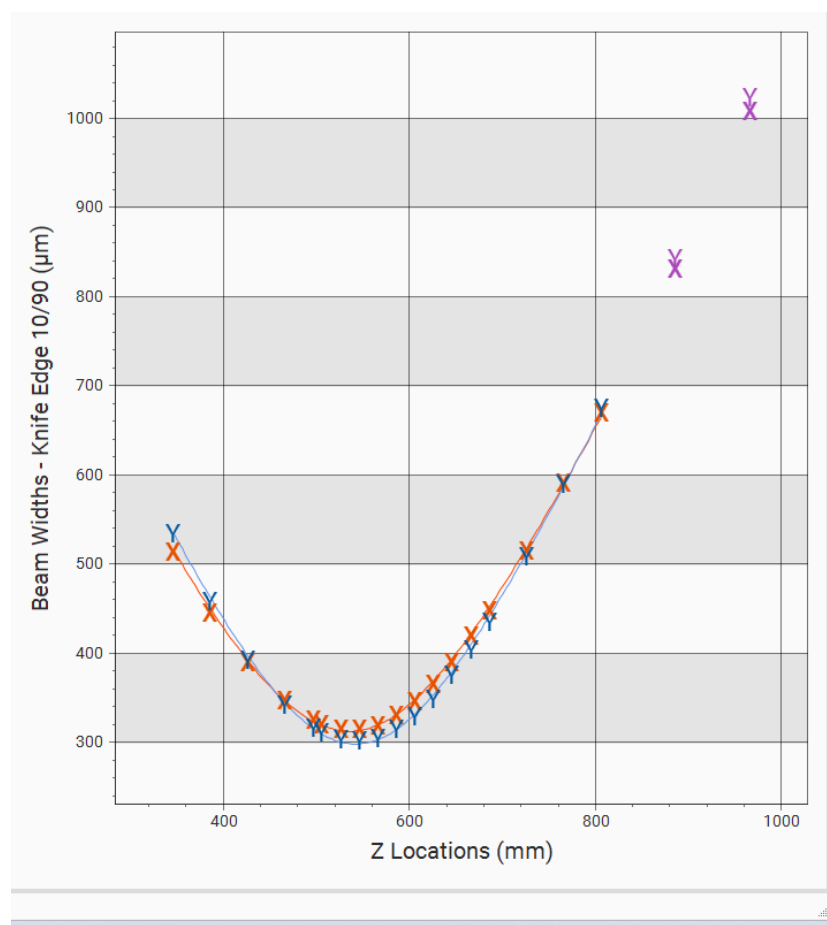
1064 nm Power Level: 5 - 50 W
Rb, Cs, Na, Yb, Sr, Ca, Ba, K, Dy
532 nm Power Level: 1-3 W
Ba, Dy
1070 nm Power Level: 1-5 W
Li

Ampheia™ Series | Ultra-low noise, single-frequency, CW fiber laser systems



		Ampheia™ 532 nm	Ampheia™ 1064 nm		
Wavelength in air		532.1 ± 0.3 nm	1064.2 ± 0.6 nm		
Available Power Levels		5 W	20 W	40 W	50 W
Output power range*		1 % to 100 %	5 % to 100 %	2.5 % to 100 %	2 % to 100 %
Spectral linewidth (FWHM, 1 ms)		< 100 kHz	< 50 kHz		
Optical signal to noise ratio (OSNR)		> 70 dB			
Wavelength stability (±2°C and 8hrs)		< 1 pm			
Power stability (±2°C and 8hrs)		< 1.0 %	< 0.5 %		
Noise, 100 Hz - 10 MHz (rms)		< 0.1 %	< 0.05 %		
Relative intensity noise (RIN)	1 kHz - 100 kHz	< -125 dB/Hz	< -130 dB/Hz		
	100 kHz - 1 MHz	< -130 dB/Hz	< -140 dB/Hz		
Beam diameter at aperture		1.0 ± 0.2 mm			
Beam symmetry at aperture		> 0.90:1			
Spatial mode (TEM ₀₀)		TEM ₀₀ (M² < 1.05)			
Beam divergence (full angle)		< 0.9 mrad	< 1.7 mrad		
Beam pointing stability		< 5 µrad/°C			
Polarization extinction ratio (linear, vertical)		> 1000:1 [> 30 dB]			
Delivery fiber cable length		1.0 m			

* The beam parameters may vary with output power and can only be guaranteed at nominal power.



The performance of Ampheia™ has been rigorously evaluated through a series of experimental setups designed to measure RIN, beam quality, OSNR, linewidth and power stability. Recent experiments have demonstrated that the Ampheia™ laser systems achieve outstanding ultra-low noise characteristics without active noise cancellation techniques, which is a critical parameter both for maintaining coherence in quantum systems and for achieving ultra-high resolution in particle analyzing equipment. Thanks to the use of a diode-pumped laser as the seed source, the emission is also free of amplified spontaneous emission (ASE), providing improved OSNR compared to systems using a semiconductor laser as seed source. Active temperature stabilization of the optical platform in the beam delivery head ensures a very high level of beam pointing stability, also in varying ambient environments.

References

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- [4] Reisenbauer, M., Rudolph, H., Egyed, L. et al. "Non-Hermitian dynamics and non-reciprocity of optically coupled nanoparticles," Nat. Phys. 20, 1629-1635 (2024).
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SUMMARY

The Ampheia™ fiber laser system: A high performance fiber amplifier w/ integrated DPSS seed

Here we present the Ampheia™ fiber laser system: A high performance single-stage fiber amplifier with an integrated DPSS ring-cavity laser seed source. Providing high power single-frequency CW emission at 1064 nm and 532 nm, the Ampheia™ system achieves low noise performance without active noise cancellation.

The compact, easy-to-use platform is a top candidate for quantum, particle counting, and laser pumping applications and is available at a price point that is attractive to end users and OEM integrators alike."