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Hybrid External Cavity (HECL)

LINEWIDTH MEASUREMENTS

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Innovative Photonic Solutions Hybrid External Cavity (HECL) Linewidth Measurements

Innovative Photonic Solutions' Hybrid External Cavity Laser (HECL) has been described previously [1,2] to stabilize both single- and multiple-spatial mode semiconductor lasers for a variety of applications that span visible to infrared wavelengths. Using this proprietary technology, it is possible to isolate a single-longitudinal-mode of a single-spatial mode semiconductor laser with very narrow linewidth. Standard product measurement of the laser linewidth at Innovative Photonic Solutions is provided by ANDO AQ6317B or AQ6315E optical spectrum analyzers (OSA) with a limited resolution of 0.01-0.02 nm. Evaluation of the spectral linewidths of single-spatial-mode lasers on these OSAs' measure at the instrument resolution of 0.01-0.02 nm; while multi-spatial-mode lasers measure < 0.1 nm. Thus, our standard product measurement does not have the required resolution to accurately measure the line width of our single-spatial-mode / single-longitudinal mode lasers.

The measurement of laser linewidth below 1 MHz is normally done using a self-heterodyne method. The method we use is described by Tsuchida [1]. In Figure 1, we show a self-heterodyne beat spectrum displayed on spectrum analyzer with a resolution bandwidth of 1 kHz. We observe a laser linewidth of 26 kHz. The lowest linewidth we have ever achieved was measured by one of our customers at 10KHz. All the lasers tested had both their temperature and laser controlled by digital based electronics, which normally meets the needs of our customers. Our customers normally measure linewidths from about 5 MHz to 20 MHz depending on their drive electronics. The HECL laser linewidth is typically about 100 kHz but is limited by our operating electronics. Reduction below this level requires driver electronics that will have a very low noise analog laser driver along with a design for dual TECs for improved temperature control to remove wavelength jitter.

A quick example will help to explain this. The HECL laser has a wavelength versus temperature coefficient of ~ 0.007 nm / °C. At 970 nm, 1 MHz linewidth corresponds to 3.1×10^{-6} nm. Therefore, the temperature stability required to maintain this linewidth equals [3.1×10^{-6} nm] / [0.007 nm / °C] ➔ 4.53×10^{-4} °C; which corresponds to +/- 200 micro-Kelvin. In order to maintain this precision of temperature stability, the laser must be enclosed within an insulated box which is separately temperature controlled on another TEC.

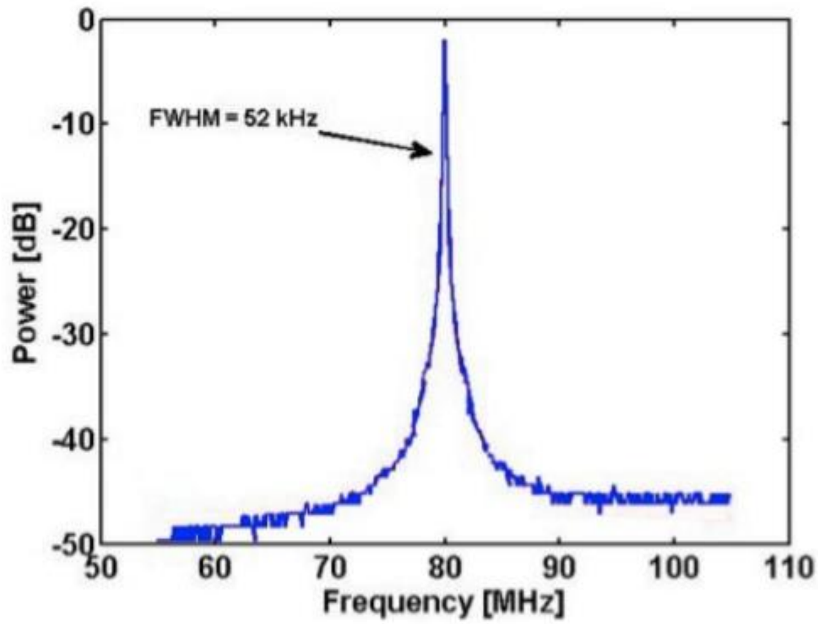

Figure 1: Self-heterodyne beat spectra on a spectrum analyzer with a resolution of 1 kHz for an IPS HECL laser operating at 970nm with a laser linewidth of 26 kHz.

[1] S.L. Rudder, J.C. Connolly, and G.J. Steckman "Hybrid ECL/DBR wavelength and spectrum stabilized lasers demonstrate high power and narrow spectral linewidth", Proc. SPIE **6101**, Laser Beam Control and Applications, 61010I (2006).

[2] US Patents 7,889,776, 9,287,681, 9,577,409, and 10,090,642.

[3] Hidemi Tsuchida, “Simple technique for improving the resolution of the delayed self-heterodyne method”, Optic Letters, Vol.15, No. 11, (1990).