New and future capabilities for CW laser power measurements at NIST.[†]

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As the commercial, industrial, and military applications for lasers expand, so do the demands that customers place on the calibration services that NIST provides. Calibration services in the CW Laser Radiometry Project of the Optoelectronics Division at NIST meet many of these needs and continue to expand to meet new needs. This Project focuses on selected critical parameters intrinsic to sources and detectors, especially the calibration of optical-fiber power meters and laser power or energy meters at commonly used wavelengths and powers or energies. In addition, special test measurements are available for linearity, spectral responsivity, and spatial and angular uniformity of laser power meters and detectors. This presentation will explore recent developments in laser sources and standards for improving calibrations of laser power and energy.

Standards:

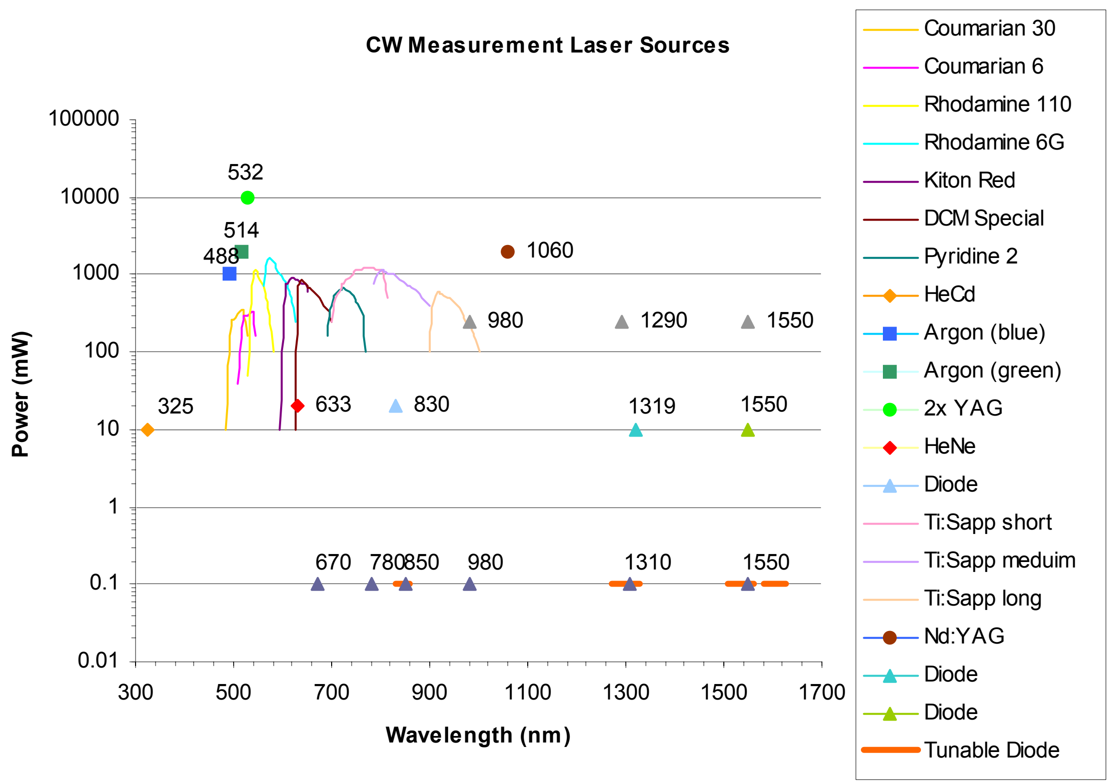
NIST has historically used electrically calibrated laser calorimeters to provide traceablility for calibration customers to the SI units for laser power and energy with ~ 0.5 % uncertainty (using a coverage factor K=2, which defines the 95 % confidence level). We also now have measurement services available based on a Laser Optimized Cryogenic Radiometer (LOCR), which provides improvement in accuracy by an order of magnitude for measurements of laser power. Using suitable transfer standards, we can now provide calibrations with uncertainty of ~ 0.05 % (K=2). To meet the increasing demands for higher accuracy over a larger range of optical power and wavelength, it is necessary to improve the accuracy of calibration services through the development of better transfer standards, traceable to LOCR. New capabilities for Optical Fiber Power Meter (OFPM) measurements have also been added, along with the addition of new tunable diode lasers. Accuracy of the OFPM has been improved through the use of a specially designed transfer standard with high collection efficiency up to NA = .25. Uncertainties are now ~ 0.3 % (K=2) for OFPM calibrations. In addition, calibrations up to 10 Watts in fiber will soon be available.

Sources:

Wavelengths and maximum power levels of lasers available as calibration sources are shown in Figure 1. Improvements have been implemented that include new or upgraded fixed-wavelength lasers to increase wavelength selection and power level availability. Under development, are tunable laser systems that will allow for greatly expanded wavelength availability and increased power levels. Among these systems are tunable dye and Titanium:Sapphire lasers yielding a tuning range from visible to the near infrared. With the addition of a stabilized frequency doubler, shorter wavelengths down to the ultraviolet can be reached with the tunable lasers. For example, doubling the Titanium:Sapphire laser yields roughly 10 % of the power from the pump laser, which should yield the highest output of 200 mW at roughly 387 nm. Along with the increase in wavelength range, these systems will incorporate high-power pump lasers. This will enable higher power levels not only for the tunable systems, but also allowing for calibrations directly with the higher powers at the specific pump wavelengths. New tunable diode lasers are now available for OFPM measurements, which gives tunable fiber-source capability in the C-band (1510-1580 nm), L-band (1551-1632 nm), II-band (1270-1310 nm), and Ib-band (830-860 nm).

Future plans for the tunable laser systems include a CW Optical Parametric Oscillator, which will allow a broadly tunable range from 1000 nm to 2000 nm. Currently, power output estimates from this system are not available. To further increase the capabilities of the CW measurements project, plans are being developed for exporting the laser signals to other calibration facilities via fiber optics. Principally, the LOCR lab and the OFPM lab will be the destination facilities for optical fiber transport. This will allow the OFPM and LOCR measurements to become available at a broader range of wavelengths.

Figure 1.



Currently available sources for CW Laser Power and Energy Calibrations:

Given the nature of tunable CW lasers (excluding diode lasers), output power is highly dependent upon pump power, wavelength selection, and linewidth. The above chart lists both fixed and tunable laser sources that are currently in use or under development. The output power of the tunable systems is likely to increase with the addition of a more powerful pump laser. The result is expected to yield an increase of a factor of 2 in output power of both the dye and Titanium:Sapphire lasers.

References:

1. NIST Technical Note 1297:1994, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Barry N. Taylor and Chris E. Kuyatt.
2. NIST Optoelectronics Division Documents and Publications: http://www.boulder.nist.gov/div815/