Radiation Hardness Studies of Butterfly Single Mode DFB Lasers at 1064 nm

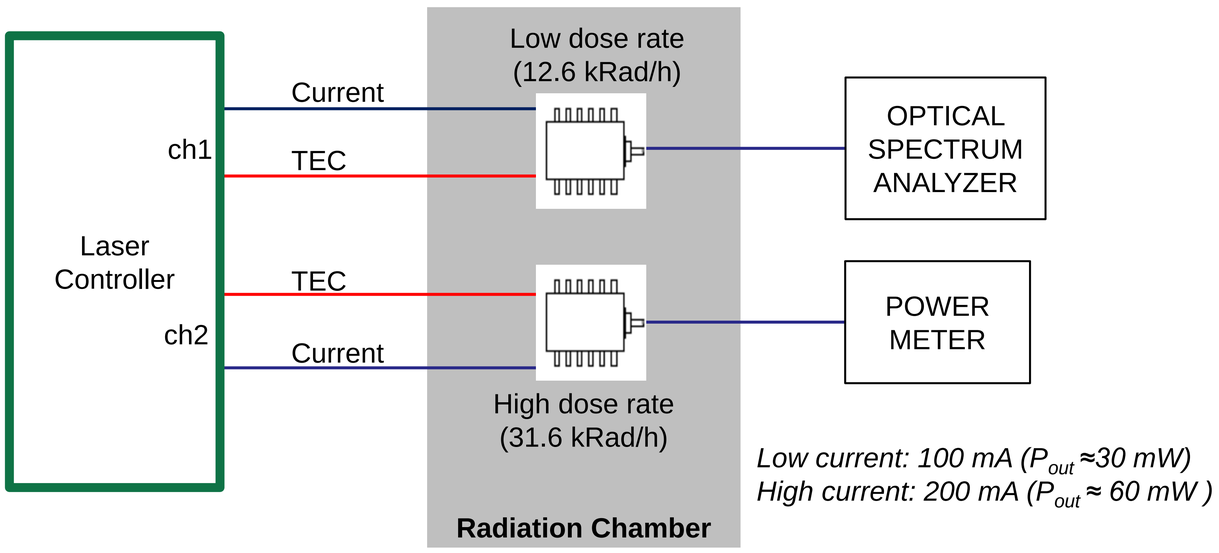
ADRIAN ZEPEDA[1], SHIVARAMAN ASODA[1], WIKTOR WALASIK[1], ROBERT E. TENCH[1], JEAN-MARC DELAVAUX[1], YASUNARI MAEDA[2], YUTAKA ONISHI[2], AND KEIZO TAKEMASA[2]

[1]CYBEL LLC, 62 Highland Ave., Bethlehem, PA 18017, USA
[2]QD Laser, Inc., 1-1 Minamiwataridacho, Kawasaki-ku, Kawasaki, Kanagawa, 210-0855 Japan
e-mail: adrian.zepeda@cybel-llc.com

Motivation and Scope of the Work

- Packaged distributed feedback (DFB) lasers at 1064 nm are critical components of space-based fiber laser transmitters and amplifiers.
- We report radiation hardness studies of the performance of QD Laser 1064 nm packaged DFB lasers (QLD1061).
- Exposure: 662 keV gamma radiation, total doses up to 250 kRad.
- Passive and active tests: output power, optical signal-to-noise (OSNR), output spectra, and polarization extinction ratio (PER).

Experimental Setup



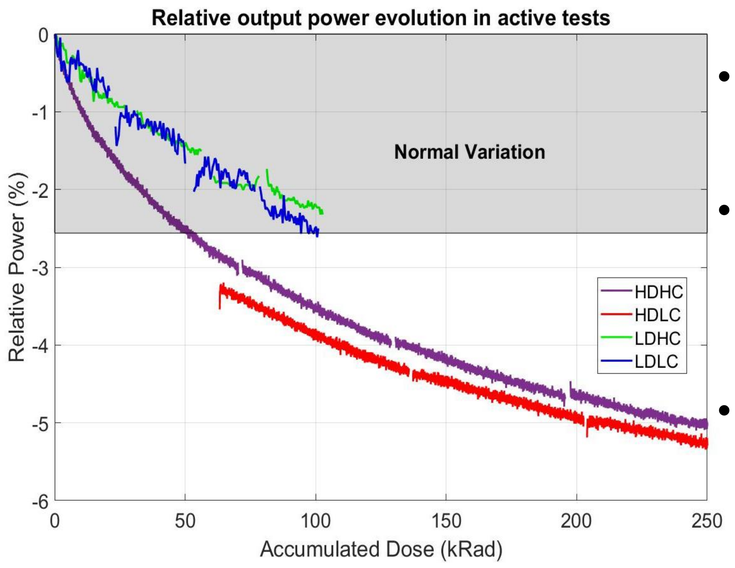
Low current: 100 mA (P_{out} ≈30 mW)
High current: 200 mA (P_{out} ≈ 60 mW)

- Figure 1 shows the experimental setup for the active laser tests.
- The radiation environment for passive tests was similar (dose rate of 15.6 kRad/h).
- Sample sizes were 8 lasers for the passive tests and 4 lasers for the active tests.

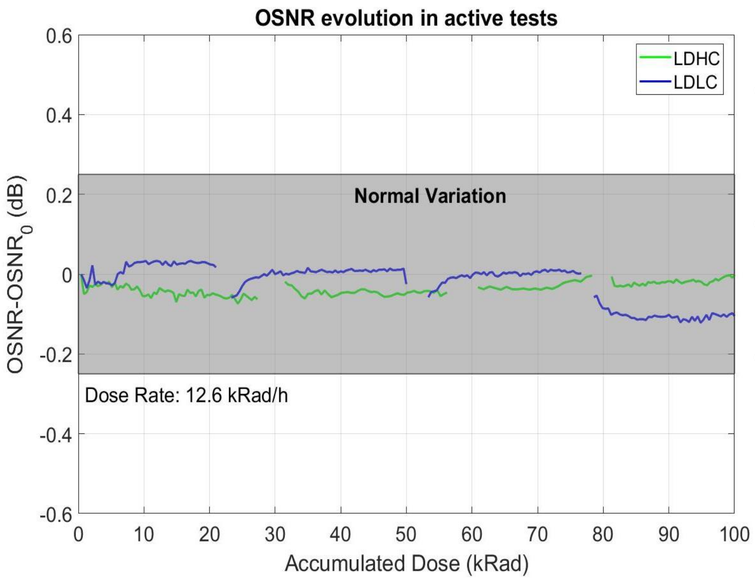
Active Test

SAMPLE DEFINITION:

- **HDHC – High dose rate, high current.**
- **HDLC – High dose rate, low current.**
- **LDHC – Low dose rate, High current.**
- **LDLC – Low dose rate, low current.**



- Figure 2 shows the percentage change in output power as a function of the accumulated dose.
- **Samples exposed with a low dose rate showed a change within the variation observed under normal operation conditions (2.5% of the initial power).**
- **Less than 5% decrease of output power for doses of up to 250 kRad.**

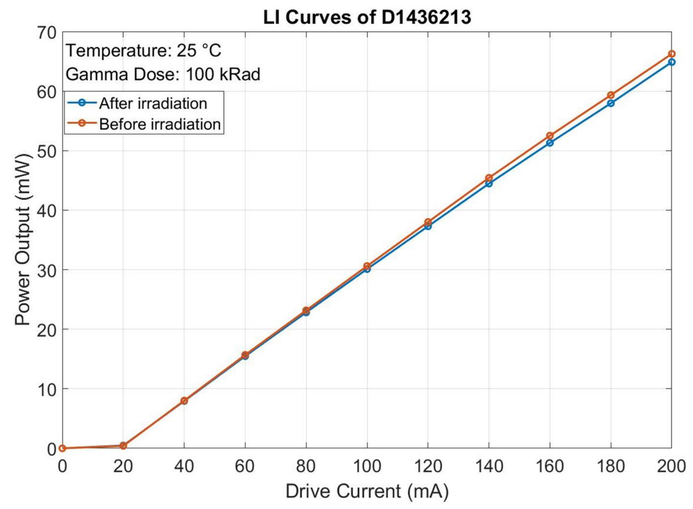


- Figure 3 illustrates the measured change in OSNR values during the active tests.
- **OSNR change is within the variation observed under normal operating conditions.**
- **The peak wavelength variation remained smaller than the OSA resolution of 0.05 nm.**

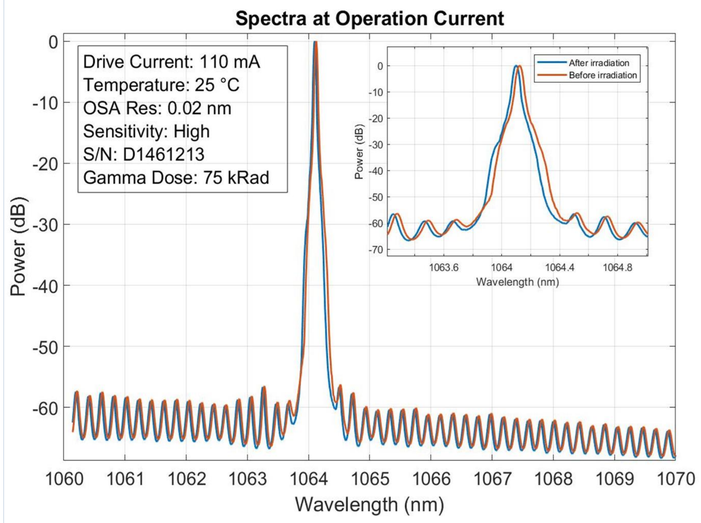
References

- https://photonics.gsfc.nasa.gov/tva/meldoc/NEPP/2008/NEPP-FiberAmplifierReport-08.pdf
- https://www.osti.gov/servlets/purl/919636/

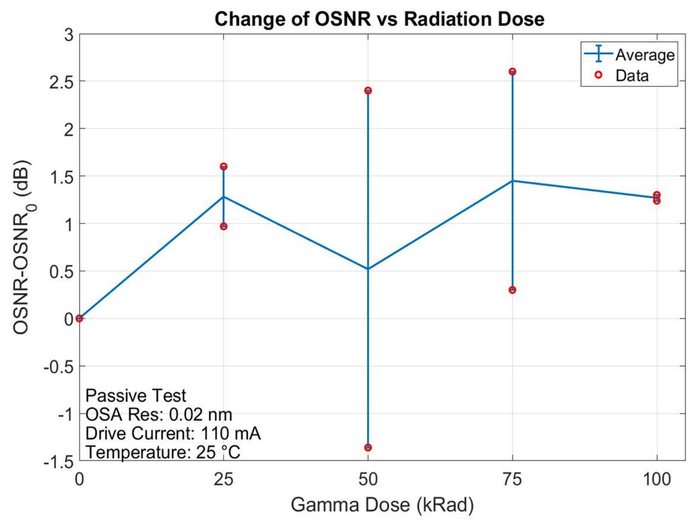
Passive Tests



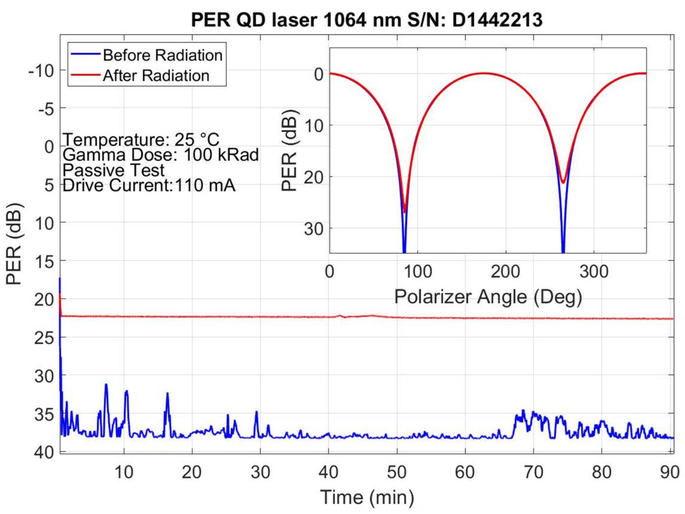
- Figure 4 plots LI curves before and after a total dose of 100 kRad of irradiation delivered at a dose rate of 15.6 kRad/h of a representative 1064 nm DFB.
- **The change in output power after irradiation is less than 3%.**



- Figure 5 shows spectra for the passive test before and after 75 kRad irradiation for a selected DFB.
- This selected laser exhibited the largest change in center wavelength after radiation exposure.
- **The measured change in peak wavelength for this DFB is less than ±0.032 nm, which is comparable to the ±0.02 nm reproducibility of the OSA.**



- Figure 6 plots the measured change in OSNR for the 8 lasers passively tested as a function of a total dose up to 100 kRad.
- **The measured change in OSNR values was a maximum of +2.6/-1.4 dB, and represents only a small variation in the mean measured OSNRs of 56–58 dB.**



- Figure 7 plots the temporal stability of the polarization extinction ratio (PER) for a selected DFB laser, before and after irradiation with a total dose of 100 kRad. The inset shows the PER visibility curves.
- **The PER after irradiation is > 22 dB.**

Conclusions

- Variation in output power < 3% up to 100 kRad.
- Shift in peak wavelength for both passive and active tests < ±0.032 nm.
- Change in OSNR < +2.6/-1.4 dB.
- Polarization Extinction Ratio > 20 dB after 100 kRad.
- **Summary: QLD1061 packaged DFB lasers are robust with respect to gamma irradiation up to 250 kRad**.

Future Work

- Performance measurements of 1064 nm DFB lasers with protons and heavy ions (Fe^+, He^+).
- Thermal / vacuum measurements.
- Influence of radiation on the laser linewidth.