SPECTRAL AND GEOMETRIC PROPERTIES OF LASER BEAM IN RELATION TO LASER DIODE OPERATING TEMPERATURE

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ABSTRACT

Present day optical wireless communication systems work with wavelength of 1550 nm but it is considering whether optical communication at 850 nm offers more benefits. Currently we don't know answer on the question which optical window is more reasonable to use in free space optical links. This paper is focusing on the relation between laser diode operating temperature and spectral linewidth, we also observe optical intensity distribution in beam of the laser diode. We select laser diode which emits wavelength of 1550 nm (RLT1550-15G). The point of the research is to examine spectral and geometric properties of this laser diode.

1. INTRODUCTION

We investigate whether operating temperature of laser diode can cause convergence or divergence of the laser beam. We demand narrow optical beam (ϕ divergence is about 3 mrad) in optical communications [1].

In case of temperature influence on laser beam geometry it is necessary to change distance between laser diode and transmitting lens. In range of temperature changes we tested spectral line amplitude variances. In case of significant spectral line decrease together with spectral line expansion we have to consider if interferential filter can decrease received optical signal.

For spectral linewidth measurement in range of temperatures (20°C - 45°C) Fabry - Perot interferometer was chosen. This interferometer is designed for spectral line measuring at wavelength 1550 nm and can exactly determinate spectral linewidth. We are going to observe spectral linewidth changes due to increasing laser diode operating temperature. Outcome will be displayed on oscilloscope.

Optical intensity distribution in relation with temperature variation is scanning by laser beam profiler (LBP). It was added objective to get complete laser beam spot on CCD sensor. We are able to specify beam radius and correlation factor between laser beam and Gaussian distribution. Final map of optical intensity distribution in laser beam is depicted by appropriate software.

2. SPECTRAL LINEWIDTH AND OPTICAL INTENSITY DISTRIBUTION MEASURING

One of the most important parameters of laser sources is spectral linewidth and geometrical halfwidth of the beam. Relation between optical intensity $I(x,y)$ and total optical power P is given by following expression [2]

$$P = \int_S I(x,y)dS\,, \tag{1}$$

where $I(x,y)$ is function of coordinates x and y and dS is elementary surface.

When laser source radiates Gaussian beam used following expression is relevant

$$P = \int_S I_0 e^{-2\left(\frac{r}{w_0}\right)^2}\,, \tag{2}$$

where I_0 is maximum of optical intensity, r is radial distance from beam axis and w_0 is laser beam halfwidth.

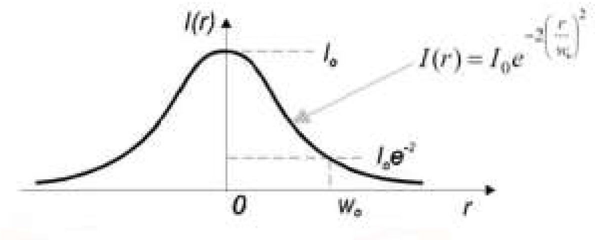


Figure 1: Gaussian beam distribution [1]

We determinate spectral linewidth of Gaussian beam by finding distance between two points which optical intensity value is half in comparison with maximum of optical intensity. We can also observe wavelength variation with changing temperature but this effect isn't point of this paper so we are going to study spectral linewidth changes only.

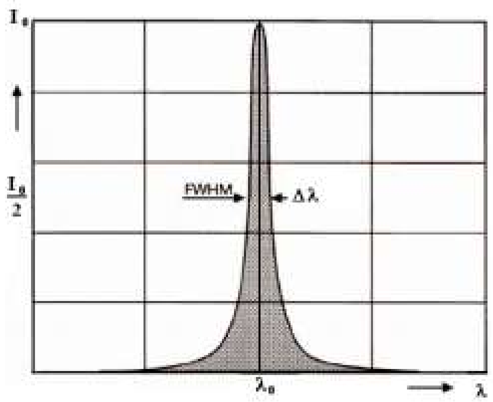


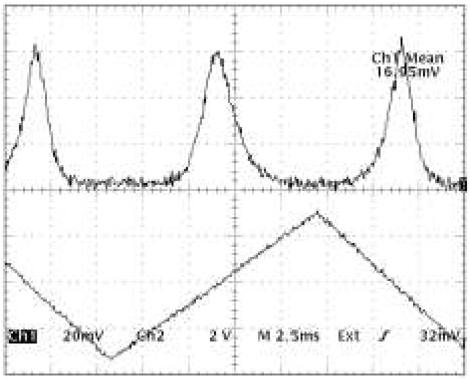
Figure 2: Spectral linewidth FWHM = $\Delta\lambda$ [2]

Following section is dedicated to spectral linewidth and beam geometry measurement. Variable quantity is operating temperature of laser diode.

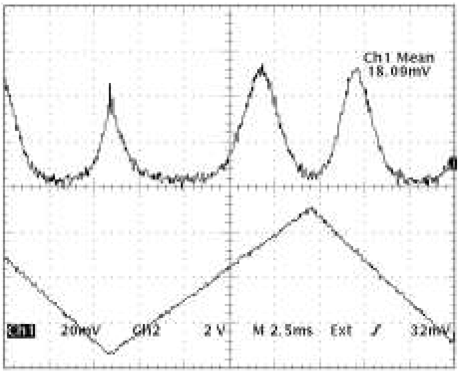
3. EXPERIMENTAL RESULTS

We were measuring spectral linewidth for operating temperature 20°C, 35°C, 40°C and 45°C. Following images represent results.

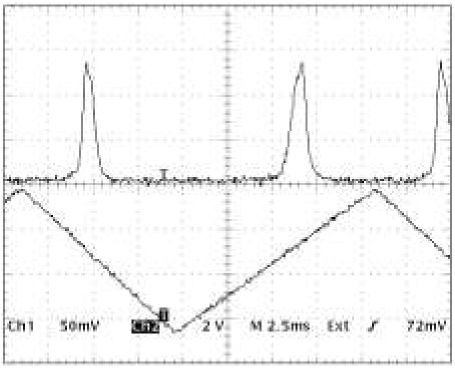
Operating temperature 20°C



Operating temperature 35°C



Operating temperature 40°C



Operating temperature 45°C

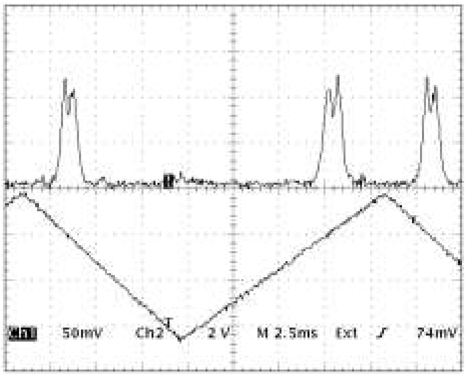


Figure 3: Measured spectral lines

Values of spectral linewidths determinated by oscilloscope depicted above are showed in following chart:

operating temperature T [°C]	linewidth $\Delta\lambda$ [nm]
20	2,0
35	2,4
40	2,5
45	2,8

Chart 1: Laser diode operating temperature vs. spectral linewidth

Visual demonstration relation between laser diode operating temperature and spectral linewidth is proper shown in the following graph:

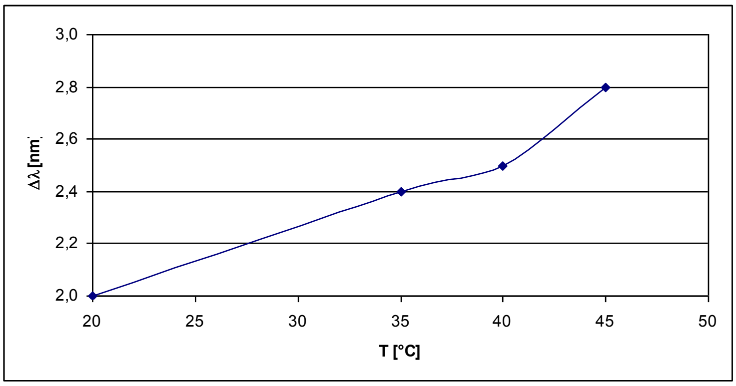


Figure 4: Laser diode operating temperature vs. spectral linewidth

Optical intensity distribution and determination of beam halfwidth at x and y axis in relation to operating temperature were proceeded by LBP. Following pictures represent resultant optical intensity distribution in relation to laser beam operating temperature.

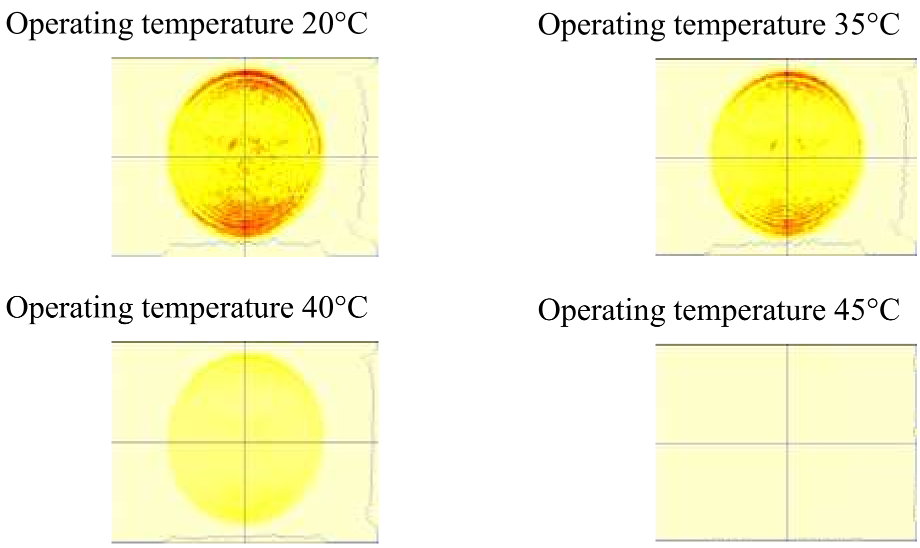


Figure 5: Optical intensity distribution

By the help of LBP beam widths were measured. Beam widths in x and y axis were determinated and Energy Equivalent Beam EEB was calculated [3]. Following chart displays results.

operating temperature T [°C]	width (x) $2w_x$ [mm]	width (y) $2w_y$ [mm]	EEB $2w_s$ [mm]
20	8,8	8,6	8,7
35	8,9	8,7	8,8
40	9,1	8,8	8,9
45	9,5	9,0	9,2

Chart 2: Beam widths in relation with laser diode operating temperature

Measured and calculated results are demonstrated at following figure:

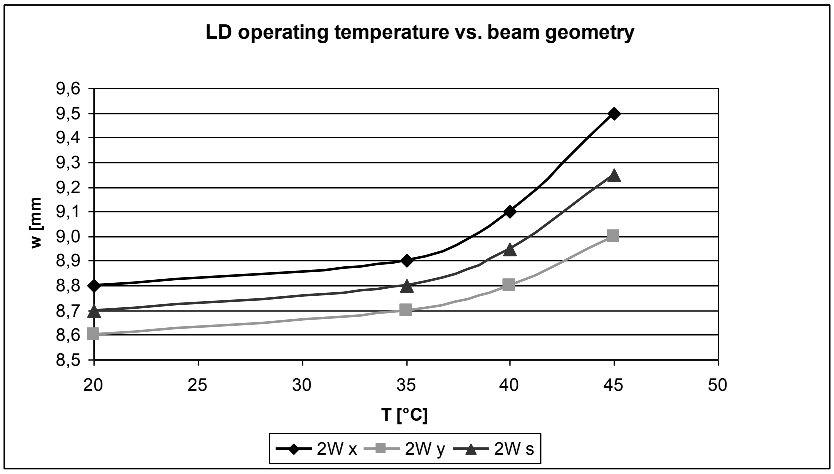


Figure 6: Beam widths vs. laser beam operating temperature

4. CONCLUSION

On the basis of measured values we can say that increasing operating temperature of laser diode causes spectral linewidth expansion and we also observe spectral line splitting at value of 45°C.

Studying relation between beam geometry and laser diode operating temperature following conclusion can be claimed. Increasing laser diode operating temperature extends laser beam. To sum up laser diode temperature stabilization is essential to avoid unsolicited laser beam extension.

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