Position Monitoring for Efficient Processing

Saving time and costs with an integrated PSD

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Appreciating beam alignment

Let's assume you have an alarm at home like the one displayed above. In order to silence it, you have to hit the bull's eye with the beam of a laser pointer. While this is an easy task with a red laser, it would be much more challenging with an invisible infrared laser. If the beam diameter and the target are shrunk to a few micrometers, your morning would definitely be ruined.

Maintenance of laser systems

Laser engineers face a comparable situation during the maintenance of a laser system: a beam needs to follow a specified beam path with µm-precision. Misalignment of mirrors or other optical components causes the beam to be deflected. Besides thermal drift of the system, the slight displacement of optics over time leads to this misalignment. During a typical maintenance, all mirrors and optics are readjusted. In order to determine the beam position at a specific location in the beam path, oftentimes the laser system needs to be opened to access the desired location. This is a tedious and time consuming process. Furthermore, it constitutes a safety issue for medium to high power laser systems which sometimes require the surrounding production environment to be shut down.

Measuring beam position & power

An integrated position detector allows you to measure beam position as well as average laser power. Without opening the laser system, the user can easily obtain the information necessary to control beam position. Such a detector can be placed at one or more positions in the beam path to provide feedback on the current beam alignment. In the following paragraphs, we present the results of characterization measurements for our thermopile position sensitive device (PSD), the gRAY C50-PC.

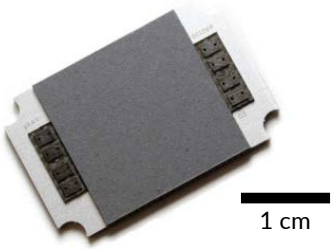

Figure 1: *gRAY position detector C50-PC. Based on a thermopile sensor, it is sensitive from UV to IR. The compact detector is mounted onto an aluminum plate for thermal management and easy fixation.*

Functionality and read-out

The PSD is based on a thermopile detector. For a standard power sensor, all thermocouples in the module would be connected in series for the signal read-out. To form the PSD, only the thermocouples in each quadrant are electrically connected to divide the total area into four electrically separated regions. Due to the common mechanical integration, a thermal coupling is still provided between all segments.
When illuminating one of the sections with a laser spot, the output signal of this segment increases, whereas the other segments will show a low signal output. If the beam is moved towards the center, the signal of this section starts to decrease. The other three signals increase on the other hand, since the power detected in those sections is higher when the beam is closer to the center of the PSD.
The x and y-position of the incident laser beam can be determined by relating the recorded signal for all four segments. Hence, a direct read-out of the laser beam position is possible.

Scanning across the sensor

The normalized sensor output for the y-position is shown in Fig. 2. The laser spot of a 1 W, CW, 1064 nm laser was scanned across the surface with a step size of 100 µm. A monotonous increase of the signal is observed when scanning in the y-direction. Around the sensor center, the signal increases quasi linearly. Towards the edges of the detector a saturation of the signal is observed. This non-linearity is expected for any PSD due to the Gaussian shape of the laser beam and the induced temperature profile. This effect can be compensated for during signal post-processing if requested.

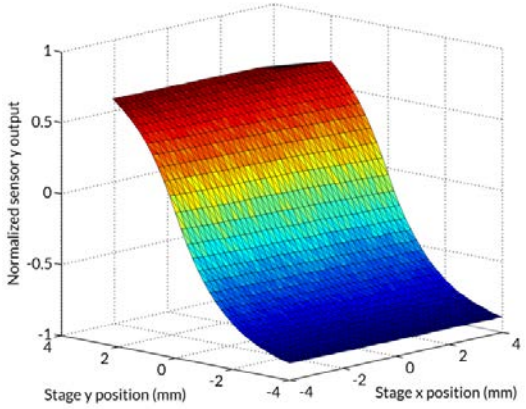

Figure 2: *y-position of the sensor signal when scanning across the sensor. A steep linear dependence is observed around the center of the sensor.*

Beam position with µm accuracy

In order to determine the position accuracy, the beam was placed at different positions on the detector. For each position, the standard deviation of the signal was converted into a FWHM of the lateral resolution. Two exemplary data sets are

x = y = 0:	**x = y = 0.4 mm:**
FWHM in x = 3.9 µm	FWHM in x = 4.7 µm
FWHM in y = 4.3 µm	FWHM in y = 4.9 µm

At these two locations, the lateral position on the detector can thus be determined with an accuracy of better than 5 µm.
The histogram in Fig. 3 visualizes this effect even more clearly.

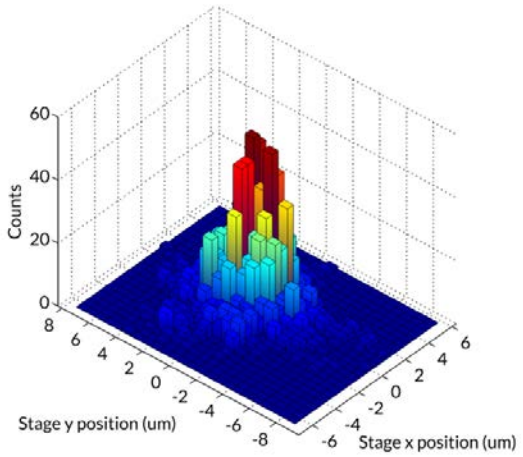

Figure 3: *Lateral resolution of the beam position measured around the center of the detector. The FWHM of the histogram shown here is <5 µm.*

Conclusion

The gRAY – C50-PC has been characterized as a position sensitive device for laser beams. The results presented here suggest that the lateral resolution is as low as 5 µm at 1 W. Further, the short rise time of only 250 ms (common for all C-type gRAY detectors) ensures fast feedback. Because of its compactness, the detector is ideal for OEM applications.
Integrating a PSD into a laser system allows for an improved knowledge of the laser parameters power and position. This information translates directly to a higher process efficiency and quality.

Finding an even better solution

As an SME with an excellent R&D and production team, greenTEG can react to the customization demands of customers immediately. We regularly develop customized solutions for OEM customers to meet their specific requirements. The constant exchange with customers helps us to understand their challenges. We provide suggestions for new and innovative detector units and plan developments in close collaboration with the customer.
Contact us with your application requirements and ideas!

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