Promis-Electro-Optics B.V.

Non - Contact

2/00

Latest news!

SiTek presents the enhanced light sensitivity ES-PSD! Se page 2.

Head Checking

There is a high probability that the car you are driving was - to a large extent - built by industrial robots. In this way the possibility of human errors in the assembly process can be kept to a minimum. At the same time there is still room for "robotic errors" which call for a detection of incorrectly mounted parts during assembly. In the old days vehicle quality used to be checked when the car rolled off the line but today photonic technology enables the scrutinising of quality of every process while it is being done.

A peek inside an engine assembly plant at - for example - GM, Opel, Audi, VW or Daimler-Chrysler shows laser displacement sensors from the German manufacturer GFM (Geselleschaft für Messtechnik) at work in several places. Here they solve a large range of measurement and inspection tasks, which require non-contact tracing with high resolution and high velocity. The GFM sensors operate on the principle of static triangulation. A semiconductor laser generates a small light spot onto the surface of the test object. By means of a set of high quality lenses the diffuse reflection of the spot is projected onto a SiTek linear position-sensing detector (PSD). Any displacement of the test object induces a shifting of the light spot image within the sensitive area of the PSD. The analog output of the signals of the PSD is amplified, digitised and transmitted via a high-speed serial interface for further data processing. (The interested reader can find more of the theory behind PSD triangulation systems in SiTek's 'PSD School').

A typical application is the checking of assembled cylinder heads. The GFM laser triangulation sensor (model ITS-3) carries out such a check quickly and free of contact. It checks each cylinder head while moving on the conveyor belt between two stations. A number of these sensors record the actual contour of the cylinder head centrally over the objects, which have just been fitted (figure 1). The control and evaluation processor compares this with the nominal contour of a perfectly fitted head and report errors to the station's PLC. In this way the stud bolt screwing depth and the valve assembly is checked (figures 2 & 3).

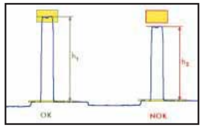


Fig.2

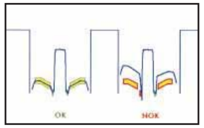


Fig.3

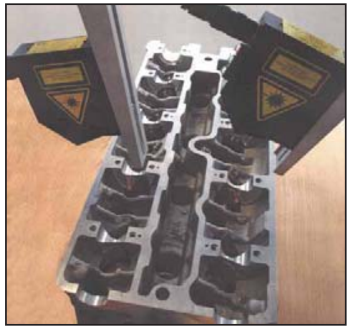


Fig.1

Car manufacturing is a conservative industry, so production-line designers have to stick to rugged, well-established and reliable technologies such as GFM laser displacement sensors.

To get optimal results from the PSD sensors in a harsh industrial environment GFM has provided its sensors with some special features:

- To reduce the influence of electronic noise the operational amplifier for the current to voltage conversion is mounted directly below the PSD to have the shortest possible length for the highly sensitive connection cables.
- The two signals of the PSD are both analog-digital converted within the sensor head. The calculation of the distance value is done digitally.
- To take into account the tolerances of the electronic devices and thermal influences on the electronics between the PSD and the A/D converter, the sensor head is automatically calibrated before every measurement. For this a constant current signal is given via a high precision dual resistor to both signal paths. The quotient of both received digitalised values is taken into consideration on calculating the distance value.
- To get optimum optical performance the PSDs are used without covering glasses to minimise optical losses and stray light is suppressed using the patented NT-type of PSD with built-in stray light suppression.

An advantage of the CCD is that, like the human eye, it can store light received until there is time to measure it. This feature can come in handy when measuring minute light quantities.

Applications:

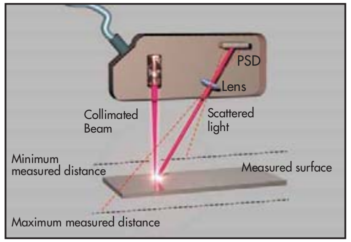
As can be seen from the above, the most straightforward and fastest way to measure the position of the centroid of a light spot is to use a PSD. In many applications this is exactly what is done. Examples are alignment systems where the position of a reference laser beam relative to the PSD is measured. Such systems are used for alignment of everything from bridges to optical systems. As PSDs can be made to operate at very low temperatures (liquid nitrogen), this alignment method has also been applied to infrared optics where the infrared radiation from the PSD must be kept to a minimum.

A weakness is that the PSD cannot differentiate between a direct beam and a reflected beam. It will just output the resulting centre of gravity from the two spots. Using a CCD in this application offers the possibility of differentiating between direct hits and reflections by evaluating the signal strength in the light spots. Of course this will add to the complexity of the system and further slow it down.

"King of Triangulation"

PSDs are widely used in displacement sensor systems using triangulation. Such a system can be made at a low cost using rather simple electronics. The downside is - unfortunately - that the condition of the surface being measured may cause considerable variations in measurement values. The texture of the surface, for example, may distort the shape of the light spot used for measurements. This will shift the centre of gravity of the light spot thus fooling the PSD. The CCD on the other hand detects the peak value and identifies this as the target position - uniformly and accurately.

Another problem is that dark surfaces, for example black rubber, have low reflectivity and a normal PSD may, unlike a CCD, encounter a low signal. To remedy this SiTek has developed a new family of sensitivity-enhanced PSDs. These devices are position-sensing phototransistors in



contrast to the standard PSD which is based upon a photodiode. The phototransistor PSD shows an enhanced light sensitivity currently giving at least five times more photocurrent for the same light input. Light sensitivity is expected to increase further, in the near future, as the fabrication processes are perfected.

Using sophisticated signal processing such as optical filtering and synchronous detection together with a PSD may solve some "impossible" measurement tasks such as measuring the displacement of molten red hot iron or taking measurements inside the arc of a welding torch.

An area where the PSD will shine is where some sort of displacement needs to be monitored without contacting or loading the member moving. Examples are non-contact explosion-proof fuel level measurements, movement of membranes in microphones, loudspeakers and pressure-sensors or optical fibres moving in wind sensors or accelerometers. Here sub-nanometer resolution could be obtained using very simple analog circuitry.

Look for more information about triangulation in the 15 Chapters of the SiTek PSD School.

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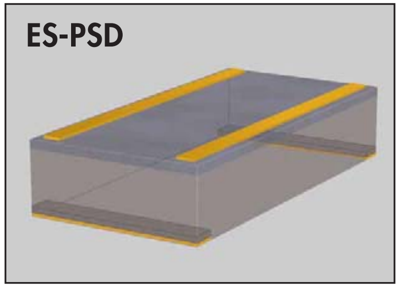
Latest news!

The world's first position sensing phototransistor - with enhanced light sensitivity!

A well-known problem area within non-contact measurement has been in applications where the measurable light is of very low intensity - such as measuring against dark, light- absorbing objects.
As solution to this problem - thanks to a long-running development programme – SiTek can today present the world's first position sensing phototransistor, designated as ES-PSD (Enhanced light Sensitivity-PSD).

This new component has a light sensitivity that is at least five times higher than SiTek's standard PSD. This makes it very useful in situations where one is operating with weak light signals. An example is in triangulation against dark surfaces such as rubber.



The new ES component is based on the same operating principle for position determination as SiTek's earlier detectors i.e. with photocurrent division in resistive layers. The difference is that this current is now generated and amplified in a photo transistor instead of a photo diode.

The advantage of the new component is that it permits measurements with much lower light intensities than a standard PSD as well as the fact that it can be controlled with a base current. This control may be utilised for switching the PSD 'on-off' or -with an external feedback - to regulate the component's amplification in order e.g. to maintain the photocurrent constant, and in this way avoid light intensity variations which could affect the position signal.

On the move....

One of the key processes in our manufacture of PSDs is ion implantation. Here we create the super homogeneous resistive layers that control the linearity of our devices. For many years we have had our implanter placed at the Chalmers University of Technology of Gothenburg. There are historical reasons for this location: SiTek started at Chalmers some 25 years ago and has since then had close and fruitful cooperation with their Solid State Technology division. Over the years both Chalmers and SiTek have been very successful and the time has now come for Chalmers to build a new semiconductor facility and aquire their own implanter. For SiTek this has been an opportunity to bring "home" the implanter and place it in a clean room built as an addition to the old one. One of the advantages of having the implanter in-house is that it is now available 24 hours a day. It is also easier to give the implanter the care it deserves. As we had to take the machine apart in order to move it we took the opportunity to have an overhaul from ion gun to target. It is now in top shape and will give many years of service in the future.

Mr.Rudenström SiTek engineer & Mr Erne from BPS, Balzers Process System Scandinavia resembling the implanter.

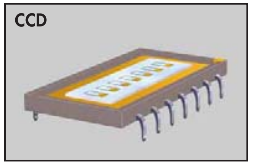
PSD vs. CCD.

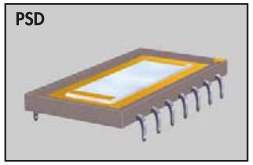
If you are facing the problem of finding the position of a lightspot on a detector surface there are essentially two ways to go: either you look at the whole picture and try to sort out what is a lightspot and where it is (the same procedure you use to find a needle in a haystack), or you use a device that only picks up light-spot positions and discards all other information (like using a magnet for finding the needle).
The first approach describes the operation of a Charge Coupled Device (CCD) and the second a Position Sensing Detector (PSD).

Position Sensing Detectors (PSDs) and Charge Coupled Devices (CCDs) are really two different breeds of cat. Both have the ability to detect light but they do it in quite different ways. The PSD gives an output that is a function of the center of gravity of the total light quantity distribution on the active area. The CCD on the other hand detects the peak value of the light quantity distribution over the active area for each pixel and the values are put out sequentially.

The eternal question: Analog or Digital?

PSDs are purely analog devices and rely on a current generated by a photodiode divided in one or two resistive layers. This simple design gives the advantages of stability and reliability. The electronics needed for signal processing of the analog output are quite simple and can be implemented at low cost.



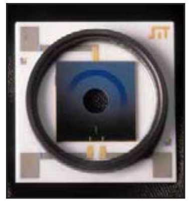


A CCD is basically an array of closely spaced MOS diodes. The light is recorded as an electric charge in each diode. Under the application of a proper sequence of clock voltage pulses the accumulated charges can be transferred in a controlled manner across the semiconductor surface to the output of the device. The much more complicated structure makes CCDs harder to manufacture and more prone to failures. The CCD gives a digital output.

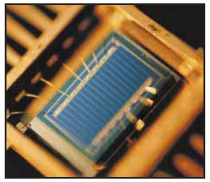
Unsurpassed speed and resolution

PSDs will measure the position of the centre of gravity of a light spot. That's about the only thing it can do, but it does it within nanoseconds with sub-nanometer resolution. Accuracy of about 0.1% is achievable and the dynamic light-range is over several decades. Using stored reference points as a look-up table can enhance this accuracy of the PSD by several decades. Usually the optical components used along with the sensor will add distortion, which can be incorporated into the look-up table and thus minimised.

As the PSD provides the position sensing information through the diodes' photo response the device can be treated as a normal large area photodiode using standard methods for signal processing such as using modulated light to avoid interference from stray light.



Circular PSD



PSD Array

A PSD can be manufactured to have any shape. Some odd examples are the helix, circular and spherical PSDs used for 2-D and 3-D angular measurements. For some applications (for example surface inspection equipment) arrays of PSDs have been designed.

Taking the whole picture.

The CCD output contains information on the light quantity distribution all over the active area and thus describes a picture. A CCD is, for example, the normal choice for the picture-catching element in video cameras.

The CCD cannot measure the centre of gravity of a light spot without additional digital signal processing and thus this type of measurement will not be as readily available as it is in the PSD. Sampling and digitally processing all the pixels will add some time and make the CCD much slower than the PSD. On the other hand, all the pixels have a mask defined position so accuracy can be very high. However, in order to reach maximum accuracy and the highest resolution, interpolation between neighbouring pixels must take place. This further slows down the process. For light spots smaller than the distance between two adjacent pixels, interpolation is not possible and the signal is lost. This sets a lower limit for the spot size that can be used.

The dynamic range of a CCD is limited and sudden shift in light intensity can give rise to blooming. This can be overcome by using the CCD sibling: the CMOS arrays. These newly introduced devices overcome many of the CCDs weaknesses when it comes to dynamic range.

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