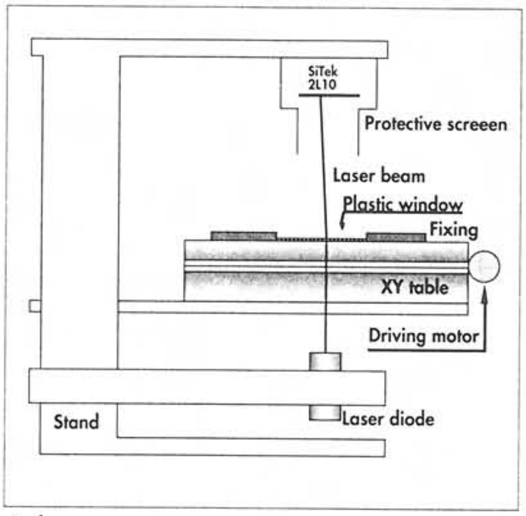
SiTek® ELECTRO OPTICS
Non-Contact
1/97
PEOPLE, PRODUCTS & NEWS

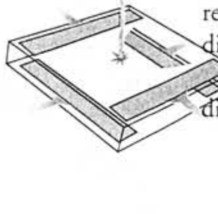
Routine checking of optical windows

A company manufacturing polycarbonate windows had difficulty in maintaining the required quality. Too many windows had to be rejected after post-production checks. However, the company believed that the number of rejections could be greatly - reduced if all plastic windows were measured up directly after removal from the injection moulding machine. This should then provide the opportunity for variation of the injection parameters and thereby continuously manufacture windows of the required precision. Each measurement should not take no more than 30 seconds, and in order to achieve a sufficiently good final underlay it should cover 30 points distributed over the entire 26 x 36 mm large surface on every window.



The solution to the problem

It was immediately obvious that the measurement must take place automatically and be suitable for operation by computer. The requirement was that a beam of light, when passed perpendicularly through the plastic window, had a maximum angle of deviation of 0,25 mrad. By recording the change in position of a beam of light that first strikes a position sensing detector (without passing through the window) and then striking the detector after having passed through the window, one can obtain the required angle of deviation as arc tan for the change in position divided by the distance of the detector from the window. That being so, one must select a collimated beam of light with a certain diameter, which means that the position sensing detector must be able to recognise the so called light centre of gravity. It is possible to solve the task with at CCD, but that will require a lot of programming and thus require higher development costs. A PSD will do this directly.



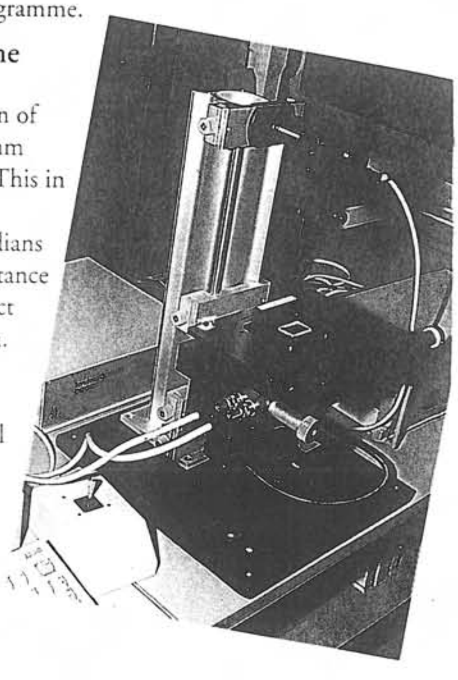
In this example, the beam of light used had a diameter of ca 3,5 mm. If the detector is placed at a distance of 200 mm from the window, and we are interested in an angle of deviation of the order of 0,25 mrad, this corresponds to a shift in the beam of light of 0,00025 x 200 mm = 0,05 mm in different directions on the PSD detector. This, in turn, means that the detector must have an active surface of at least 4 x 4 mm. We decided to chose a SiTek 2L10 which has an active surface of 10 x 10 mm, thus providing a significantly grater margin for mounting and handling of the measurement equipment.

Building up the measuring system

A fixing for the windows was mounted on the motor-driven cross-table of a microscope. Since the xy-motion is so constructed as to function on the horizontal plane, the window is placed on the same plane making it easier to change the object being measured. The PSD detector was mounted above the xy-table, with the active surface downwards and the laser diode underneath, pointing upwards. In this way it was easier to shield the PSD from any surrounding light and additional shielded by means of a tubular light shield in front of the detector. The appearance of the measuring equipment can be seen on the pictures. SiTek´s PM-kit was used for the electronics and a PC chosen to guide the measuring, with the applications being written in Visual Basic programme.

The performance of the measuring equipment

The PM-kit has a resolution of 1/2000 which, on the 10 mm detector used, gives 5 µm. This in turn means that an angular resolution of 0,005/200 radians = 0,025 mrad when the distance between the measured object and the detector is 200 mm. Thus the resolution is one-tenth of the maximum allowed deviation. The total measurement time to measure all 30 points is 16 seconds.



Customer support and Development

Two concepts at SiTek which, for a long time, have been closely connected, are customer support and development. Where other companies have R&D department we have a C&D department; in fact, during the past few years we have prioritised customer support. Development work has mainly been concerned with acute problem-solving for customers. Of course, this has sometimes generated such knowledge as to lead us to either the further development of our process or the creation of totally new components. Right now we are making a substantial investment in both development and the improvement of customer support. We have therefore appointed two very competent colleagues, whose respective presentations appear below.

Customer support

If the close connection between customer support and development has, to a large extent, depended on practical considerations it has also been, and will continue to be, part of the SiTek philosophy. In our opinion customers are most important and we do our very best to live up to this. Without close contact with you customers are we not able to develop the component you need. We work for you. Even in the future, therefore, C will continue to come before D, i.e. customer support will always receive priority over development. The difference is that we shall now have a significantly greater capacity and competence to respond rapidly to customers questions; design quickly customer specified components, solve customers problems relating to the use of our components, and give advice on electronics, etc, all in relation to the use of our components.

Development

We shall also now have the capacity to develop our products in order to meet the demands of the future. At the same time as there is an increase in the use of Position Sensing Detectors, there also appears to be an increasing number of applications with other claims than hitherto. Parallel to the necessity for ever higher requirements relating to inspection and control, there is also a growing demand for systems involving our PSD which means, consequently, greater expectations of components. Still, it is most often other parts in the system which limit their ultimate performance, such as lenses, etc. But these continue to develop all the time so we too must keep up. We also intend to further develop our ability to produce components in several and varying shapes, i.e. circular and triangular, as well as several elements on the same chip. Last, but not least, we wish to extend our knowledge of how components perform under different circumstances and how we can influence this through our choice of process parameters.

Measuring systems

One aspect of the development of the components is to have sufficiently good internal measuring systems to check the components parameters such as leakage current, noise, resistance, linearity, thermal drift, rise time and so forth. Since there are only three or four manufacturer of Position Sensing Detectors in the world, it is impossible to buy ready-made measuring systems. We must therefore design and build these ourselves, but already we have started to upgrade all our existing measuring systems. These systems must be both sufficiently precise as to fit in with the development of tomorrow's PSD as well as being easy to operate and fast enough to function under daily production control. The upgrading of this measuring systems is a natural part of our now much-developed C&D department.

"To know is to be able to do"
Aguote Comte

Build CD stands

My name is Ulf Kokinsky and I am the latest addition to SiTek's expanding staff. My duties lie in the spheres of product development and customer support. In the spring of 1993 I obtained the Diploma of Master of Science in Engineering Physics from Chalmers, concentrating on marketing and economics. After graduating, I continued as a PhD student in the department for Ion and Semi-conductor Physics, and my Licentiate thesis is in its final stage.

I spend my free time mostly with my friends or in my workshop where, amongst other things, I build CD stands. I also like to travel and see the world.

I enjoy my work at SiTek and am sure that it will be exciting to be a part of the company's further expansion and development.

Journey to work by motorbike

My name is Torbjörn Strandberg. I am 36 years old and have been employed as a design and systems engineer at Ericsson Microwave System AB for 13 years. I have a masters degree in science in electrical engineering at Chalmers University of Technology in Göteborg. At SiTek, I will work on the design and improvement of new and old measurement systems for PSD production and will also be responsible for matters relating to the integration of a PSD in any system.

In my spare time, I divide this between my family, nature and scouting where, once or twice a week I act as a leader to a scout group of children aged between 10-15. Skiing, canoeing and rambling are other examples of my leisure activities but with spring just around the corner, I like to take out my motorbike and ride out into the countryside, just for the pure joy of it! However, most of my spare time is spent with my family; my wife, two boys aged 4 and 5 and a girl aged 6 months.

Capter 8 by Lars Stenberg ESDE AB

In section 7, I gave one method of how to optimise a collimation lens, consisting of an achromat, by selecting glass with a significantly higher refractive index than normal. I also presented some other definitions, including the optical errors in reproduction known as spherical aberration and chromatic aberration. In this section, we shall look at the requirements necessary to obtain an achromat of the required focal distance, as well as how to construct a lens system in which its spherical aberration is corrected for even greater apertures than that which is possible for an achromat.

It is common for one to use a cemented two-lens achromat as condenser in the construction of triangulation probes. The positive lens is made of crown-glass, having a relatively low refractive index and low dispersion, and the negative lens of flint-glass, having a higher refractive index and greater dispersion. If an achromat is required to be used for the entire visible wavelength range, one often corrects the achromat so that it has the same focal distance for blue and red light; but this also means that it has a different focal distance for yellow light. Now, perhaps, some objections will be raised to the effect that there is no need for a colour-corrected objective since a laser diode emits light across a narrow wavelength range. This is certainly true, but by selecting an achromat one also achieves significantly better correction of the other monochromatic aberrations or image errors. Also, further improvement can be achieved by the elimination of the need for colour correction. Accordingly, we decide to select an achromat with the focal distance of 17,1 mm.

How can we obtain an achromat with a focal distance of 17,1 mm?

If one looks through some of the more popular catalogues from firms selling optical components one finds achromats with focal lengths of 16 mm and 20 mm, but none with a focal length of 17,1 mm. So what is to be done?

There are three options. 1) One can compromise and choose one of the above two focal lengths. 2) One can combine two achromats of appropriately selected focal lengths and place them in the triangulation probe in the way shown in figure 3. 3) One can have an achromat made to exactly the required focal length and possessing the characteristics for optimising the desired effect.

Lars Stenberg

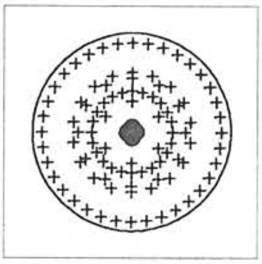


Figure 1. Spot-diagram for an achromat with a focal length of 16 mm.

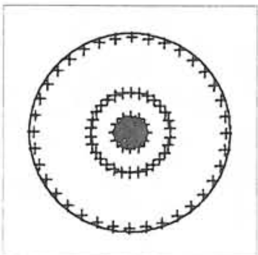


Figure 2. Spot-diagram for an achromat with a focal length of 20 mm.

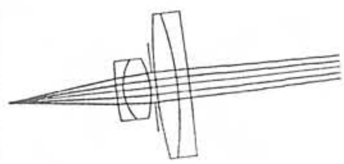


Figure 3. A combination of two achromats with focal length 20 resp. 120 mm.

Option 1

Which of the two achromats shall we choose? If we go for the one with a focal length of 20 mm we know that the beam of light will be greater than 2,5 mm in diameter if we are to employ as much light as possible. If we choose the achromat with a focal length of 16 mm the beam of light will certainly be somewhat less than 2,5 mm but, on the other hand, the diffraction will be greater. Let us therefore investigate the spot size for the two achromats. Figure 1 shows the spot for the achromat with 16 mm focal length and figure 2 shows the spot for the achromat with 20 mm focal length.

The achromat with a focal length of 16 mm and free opening of 3,3 mm (corresponding to an Airy-disc radius of 24,8 µm) has the spot radius of 22,4 µm. The achromat with a focal lenght of 20 mm and the free opening of 3,9 mm (in this case, the radius of the Airy-disc is 25,1 µm since the diaphragm lies slightly further from the laser diode on account of the longer focal length) has the spot radius of 24,0 µm. It is therefore plain to see that it is of no great significance which of the two lenses is chosen. However, if it is our wish that the optical system shall occupy as small a space as possible then we should choose the achromat with the 16 mm focal length. Why does the simple lens made of SFL6 which we designed before outperform both of the above mentioned achromats? The answer in this case is that the SFL6 lens is designed to optimise a particular application whereas both the achromats are optimised to give a good picture of an object with a certain optic angle, lying at an infinite distance.

Option 2

This implies that we employ two different achromats of appropriately selected focal lengths. We must now refer to Section 5 of the PSD school (1/96) where we determined the basic geometry of the triangulation probe and found that the suitable distance from the laser diode to the collimation lens should be 20 mm, and the distance from the collimation lens to the centre point of the measuring range, 120 mm. We shall then try to obtain an achromat with a focal length of 20 mm and place it in such a way that the laser diode ends up in the achromat's best focus. Note that it is important how one uses an achromat since its best focus lies on the same side as its negative lens element, i.e. on the side of the achromat with the longest radius of curvature. Look again at figure 3. The light leaving the achromat becomes parallel indicating that we are using an achromat with the geometry for which it has been constructed; we are, in this instance, employing the achromat at its optimum usage. If we thereafter allow the parallel light from the first achromat to pass through another achromat with a focal length of 120 mm, the result will be to obtain an optimal focus ca 120 mm being the second achromat, assuming we have set it up in the correct way. The parallel light in this instance will first meet the achromat's positive element, see figure 3! We shall therefore try to find two dissimilar achromats with focal lengths of 20 and 120 mms respectively. In Melles Griot's catalogue, for example, there is listed an achromat with a focal length of 20 mm (No LAO 11) and another at 120 mm (No LAO 134). Unfortunately the latter achromat has a diameter of 24 mm, which means that it must first be centred down if showing to be too large. Figure 3 shows how I have placed a diaphragm with a diameter of 5 mm at a distance of 0,5 mm from each achromat. Only in this instance it is not so important that the diaphragm is placed exactly here since we are working with an almost point-blank source of light. When, on the other hand, we use a similar combination as principal lens and have a greater field of view, then it is important to place the diaphragm in exactly that position so that we utilise those parts of the achromats which are impaired by the fewest aberrations. On the other hand, it is important to stop down the achromat in order to obtain the sharpest possible image. The spot size so obtained becomes 32 + 31,8 µm = 63,8 µm, and the spot's appearance is evident from figure 4. The reason for our obtaining such a small spot with the help of the two achromats is that we are working with the geometry with which they are made and thereby optimised.

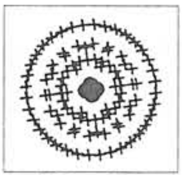


Figure 4. Spot-diagram for the combination from figure 3.

Option 3

Option 3 implies that we design an achromat for just this particular application, and we shall now see by how much the performance is improved. Figure 5 illustrates how the spot appears when an achromat is optimised for this particular application. It is made of crown-glass BAK4 and flint-glass SFL6. The free opening is 5,4 mm which corresponds to an Airy-disc with a radius of 19,8 µm, and the spot radius is 18,9 µm. The maximum diameter of the light spot for this achromat, because of the gaussic enlargement together with diffraction, becomes 30+2x19,8µm=69,7µm. Figure 6 shows the appearance of the spot when we have decentralised the laser diode by 0,3 mm. Calculations indicate the maximum decentralisation of the laser diode to be around 0,05 mm if the spot is not to suffer from too great coma errors. Thus we see that the field of view is unfortunately reduced when one optimises an achromat in order to reduce the spherical aberration as much as possible.

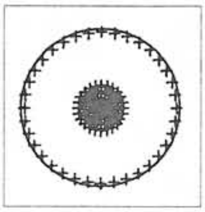


Figure 5. Spot-diagram for an achromat optimised for this particular application.

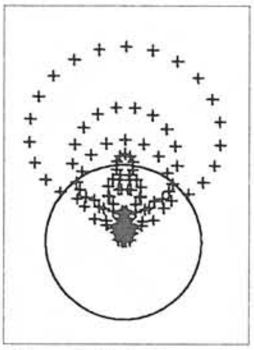


Figure 6. Spot-diagram for an optimised achromat where the laser diode is decentralised by 0,3 mm.

If one needs an even smaller spot

We must adopt a lens system with more than two lenses which are co-ordinated so as to obtain an even smaller spot. Figure 7 shows a system consisting of three lenses made in SFL6, and figure 8 shows a spot diagram for such a spot of light, the total diameter of which (geometric + diffraction) is 17,7 + 19,7 µm = 37,4 µm.

Does the above example represents a lower limit for how small a light-spot can be achieved? The answer is no. In practical terms, the spot can be made as small as you wish but we must not forget our initial requirement in that the beam of light should be quasicollimated, i.e. that the beams leaving the collimation objective should be as good as parallel. In the above example the beams of light leaving the collimation objective form a cone with an angle of 1,45 degrees, as the diaphragm has a diameter of 7 mm. This implies that the field of measurement can only be ±1 mm if we accept that the light-spot at its maximum has a diameter of 75 µm.

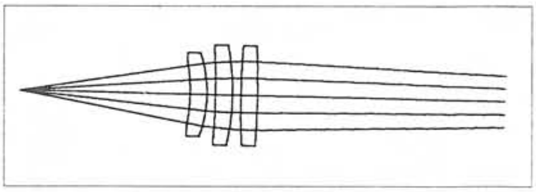


Figure 7. A system consisting of three lenses.

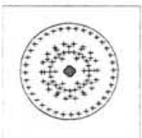


Figure 8. Spot-diagram for the lens system in figure 7.

In the next section of PSD-school I shall try to describe how one chooses the correct type of objective for the reproduction of the diffused reflected light from the measuring point on the PSD detector.

Published by
SiTek Electro Optics, Ögärdesvägen 13A,
S-433 30 Partille, Sweden.
Tel: 031-44 06 70. Fax: 031-44 14 40.

SiTek® ELECTRO OPTICS