SiTek®
ELECTRO OPTICS
Non-Contact
2/96
PEOPLE, PRODUCTS & NEWS

Opening the bottleneck

Laser-based optics and fast image processing allow Philips' paste inspection unit to perform full checking at line speeds.

Solder paste printing defects are the largest single fault source in contemporary printed circuit board production. Thorough inspection after the stencil printing stage of the assembly process is essential for manufacturing control. It enables substrates to be rejected at a point where they are easily cleaned for reuse, and before any further added value operation are performed.

In contrast, for assemblies with newer components such as BGAs, in line post-solder inspection and rework are expensive and difficult functions.

High yields are founded on close control of paste printing. However, as SMT placement speeds have risen, circuit densities increased and IC lead pitches reduced, existing techniques were failing to keep pace with flow-line production rates and creating bottlenecks.

Alternative methods such as visual examination or periodic sampling were error-prone or could only detect systematic errors.

Optical innovation

Philips "TriScan" laser scanner is a new product designed to allow full 3-D measurement of every pad on every board at flow-line rates. For example, a 300x300 mm PCB with a 0,5 mm minimum pad pith can be checked in just 9,2 s.

Central to this breakthrough is an advanced optical system that enables multi-point pad height measurements to be carried out at very high speed. Average height, volume, area, profile and misregistration can then be calculated, and clogged holes and bridging are also detected.

In the patented TriScan system, a laser beam is projected onto an angled 20-face polygonal mirror, which spins at up to 50 rotations/s to generate a reflection scanning at up to 1000 times/s. The moving beam is then reflected between a pair of "banana" mirrors, which convert its curved path into a straight, telecentric scan line of equally illuminated pixels at the PCB surface.

Light diffused by the PCB and the solder deposits is intercepted at two separate points by elliptical mirrors and each discrete beam returned through the system, to be focused onto a pair of custom built SiTek PSD's in a double triangulation module.

Accurately traversing the board beneath the scan line by means of a linear motor enables height measurement data for the whole circuit are to be gathered very rapidly. The double triangulation technique compensate for spurious reflections and is virtually insensitive to surface texture, giving a z resolution better than 10 µm.

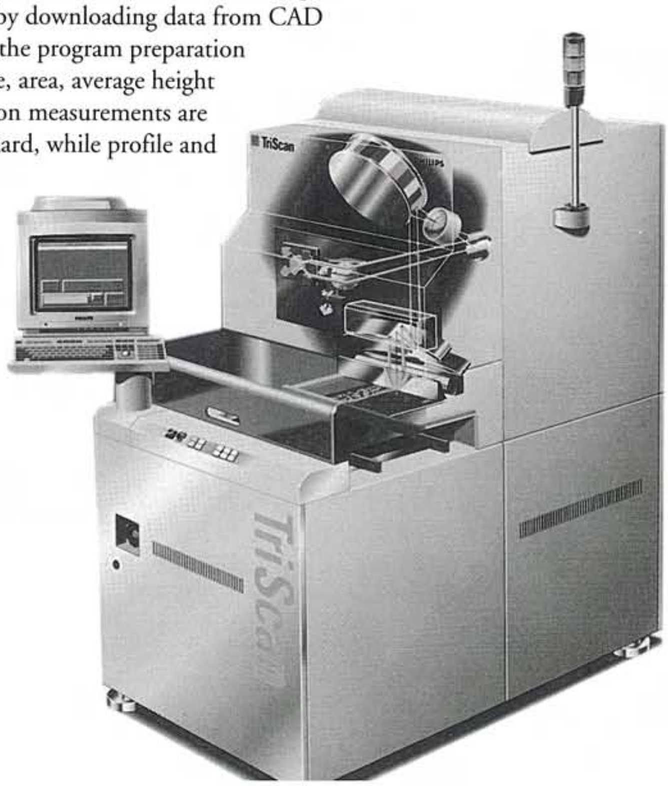
The advanced PSD processing electronics enables a pixel rate of 10 MHz with a four decade dynamic range.

The x,y resolution is adjusted by varying the mirror rotation speed and board translation rate, according to the minimum lead pitch in the circuit under test. For 0,3 mm pitch, the resolution is 18 µm, with a scan speed of 8,4 mm/s. This rises to 33,6 mm/s when pitches are greater than 0,4 mm and a 36 µm resolution can be used. At the highest speed, a fully equipped system enables up to 1600 pads/s to be checked.

Setting up the PC-controlled TriScan to inspect a circuit is done by downloading data from CAD Gerber files into the program preparation software. Volume, area, average height and misregistration measurements are included as standard, while profile and bridging checks are optional. Programs stored in the unit's host PC can be selected manually, or triggered automatically via barcode product identification.

Ing. Eric Koeken is product manager for the TriScan product. He is based at Philips EMT BV, Eindhoven, The Netherlands.

Two custom designed SiTek PSDs are used in Philips TriScan.



On the 20th anniversary







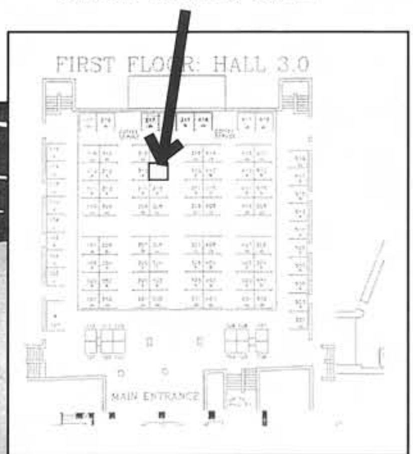

The year was 1976. Two doctoral candidates from Chalmers Institute of Technology in Göteborg set up the growth company SiTek on the basis of a high-tech innovation called PSD. Now after 20 years - and some commercial changes - it is time to celebrate the 20th anniversary. The official celebrations were launched in mid-June. Apart from celebrating the past 20 years this jubilee event also represents a leap into a challenging future. On June 13th, together with our distributors from around the world, we staked out a plan to exploit the opportunities for expansion in the sector. A trip into the Swedish countryside - radiant in summer - provided an opportunity to reinforce relationships of key significance for the company.

On June 14th which was the real date of the anniversary, we carried out a seminar programme at which distributors, customers and employees had the chance of learning more about PSD, electronics, optronics and applications. Speakers included some of the foremost experts in the sector. The programme was highly appreciated by those taking part so we are now planning to repeat this for an even wider audience.

During the Friday evening the jubilee festivities moved to the heated public bathe at Saltholmen. Here, there was an excellent atmosphere from the start and what with good food, entertainment and pleasant surroundings, nobody wanted to go home! The verdict was unanimous that we should also celebrate the 21st, 22nd anniversaries and so on in like manner.

Welcome to CLEO/Europe 1996

SiTek Stand 312



In mid-September the international laser and electro-optic trade fair, CLEO/Europe-96, is taking place in Hamburg. CLEO comprises both a technical/scientific conference and an exhibition. The conference takes place from Monday September 9th to Friday September 13th while the exhibition is held from Tuesday 10th to Thursday 12th. This is the European counterpart to CLEO / USA which has been the leading trade fair in the area of laser and electro-optic technology.

SiTek welcomes everybody to stand 312 in hall 3 where this year we shall be exhibiting with our own stand. Our broad experience and know-how in the field of PSD technology will be at your sevice.

SiTek's PSD-school

Section 6 by Lars Stenberg

In previous sections of SiTek's PSD school we examined the formulae that relate to the geometry for a triangulation probe as well as how these are applied in design. We have also calculated the focal length of the main lens and condensor optics. In addition the choice of the light source and the means of generating a so-called quasi-collimated light has been dealt with. In section 5 we discussed the choice of suitable optical components for a triangulation probe and we shall continue with this in sections 6 and 7.

How is it possible to acquire a suitable collimator lens with a focal length of 17,1 mm?

In the first place it is essential to determine what type of lens is required. Is a simple lens sufficient or must there be a lens system? In our case we want the aperture on the laser diode to be re-produced on our measurement surface which means that we therefore need a lens system with a focal length of 17,1 mm. (A lens system may actually consist of just one or a number of simple lenses, even mirrors).

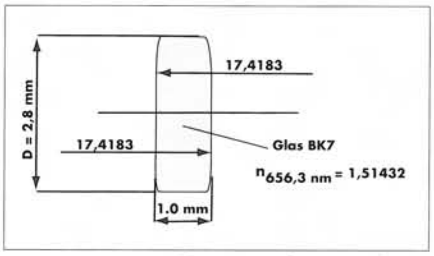


Figure 1. A biconvex lens with a focal length of 17 ,1 mm.

Let us do this with a simple biconvex lens and see how sharp a picture we can acquire. We use one of the most common optical glass types with the designation BK7 (manufactured by Schott in Mainz, Germany among others). The refraction index for BK7 at a wavelength 656,3 nm is 1,51432.

With the aid of an optical calculation program, in this case ZEMAX from Focus Software, Inc. USA, I have calculated that if the biconvex lens radius is 17,4183 mm and the thickness of the lens d= 1 mm the focal length is 17,1 mm where the refraction index is1,51432. See figure 1.

Moreover, the program has calculated that if the laser diode is at the distance of 19,599 mm in front of the lens we achieve an image of 120 mm behind the lens.

There is a further matter that we must take into consideration before we can start up the computer and allow it to estimate the light spot's diameter, which is how large will be the aperture that we shall use, ie. the diameter of that part of the lens that light can pass through. If we wish that the entire aperture shall be struck by light from the laser diode and that the last-named emits a light cone with an elliptical format cross-section the minimum angle of which is 3,5°, then half the aperture should be 19,599 x tan 3,5 mm= 1,2 mm. (on the drawing above I have chosen a lens diameter of 2,8 mm since a small edge around the lens is hidden behind the grip.)

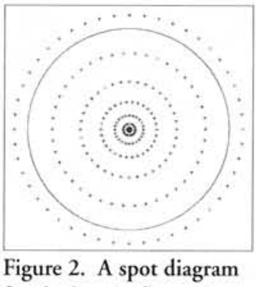


Figure 2. A spot diagram for the lens in figure 1.

Lars Stenberg

The modern optical calculation program offers a number of different opportunities when it comes to finding out whether a lens is sufficiently good for any specific task. I have chosen to emit several hundred light beames from a point on the optical axis which lies 19,599 mm in front of the lens which strikes the lens surface's free opening with a diameter of 2,4 mm, evenly distributed across the opening. Subsequently, the computer calculates exactly where each light beam hits a surface situated at a distance of 120 mm behind the lens and which is at right angles to the optical axis. Figure 2, called a spot diagram, shows where all the light beams hit the surface with the aid of a +- sign. The program also gives the radius of the light spot and it is, of course, this which interests us more in this case.

According to the computer, the greatest radius of the light spot is 46,42 µm. The computer has also drawn a complete circle that represents the so-called Airy-disk whose radius is 40,97 µm. The Airy-disk represents the diffraction that is obtained, on account of the fact that the wave-length of light is not zero and it also depends on the aperture's maximum diameter used, which in our case is 2,4 mm. In No. 1-96 of Non-Contact I reported how the radius of the Airy-disk is calculted.

Our lens is thus not diffraction-limited since different light beams lie outside the Airy-disk. This means that we can achieve a light spot of smaller diameter if we can improve the lens. Before we investigate if this is possible, we should see how good the lens calculated above really is. Since the distance between the laser diode and the lens is about 20 mm and the distance between the lens and the light spot is 120mm, the Gaussian magnification is about 6 times. This means that if the channel on the laser diode is 5 µm long the image of the channel is 6 x 5 µm= 30 µm. On account of the diffraction there is an addition of 2 x 40,97 µm which means that our light spot will acquire a maximum length of 111,94 µm. Observe that the size of the diffraction only depends on the light wavelength used as well as the free lens surface diameter.If we accept such a spot size, it is only a question of searching in different optical catalogues. For example, I found the lenses specified below in the following catalogues:

Edmund Scientific Company:

f = 18 mm bikonvex r1 = r2=18,22; d=2,2 mm; glas BK7; Diameter= 6 mm

Melles Griot:

f = 18 mm bikonvex r1 = r2=18,89; d=4,4 mm; glas BK7; Diameter= 13 mm

Spindler & Hoyer:

f= 16 mm bikonvex r1 = r2=15,18; d=7,0 mm; glas BK7; Diameter=18 mm

Since the lens from the Edmund Scientific Company is nearest the lens we have calculated, the next step is to investigate what the light spot looks like with the aid of the optical program. The result appears from figure 3 below. As appears from figure 3 the spot radius is 40,6 µm while the diffraction remains at 40,97 µm.

Does this now mean that Edmund Scientific has designed a better lens than we have done? By no means, since the distance from the laser diode to the lens must now be 20,53 mm instead of 19,599 mm in order to end up 120 mm from the lens on account of the focal length being 18 mm. It is this - as it may seem - slight difference which explains why the light spot has becom somewhat smaller. Can we then use the lens from Edmund Scientific? In order to answer this question there are two things we must answer.

In the first place; can we accept the spot´s size? Remember that it is you, in your capacity as a designer, who determines if such a light spot is sufficiently good or if we should continue to attempt to design a lens which gives an even smaller light spot.

In the second place; is there room for the lens from Edmund Scientific in our equipment? The lens we started to design requires additional length 19,599 + 1 mm = 20,599 mm and the diameter 2,8 mm whereas the lens form Edmund Scientific requires 20,53 + 2,2 mm = 22,73 mm and the diameter 6 mm. It is important that the person responsible for the mechanics has not already been allowed to draw so much for the answer to be negative. This is an example of how important it is that the optical and mechanical designers really do work side-by-side when designing an optronic product. At times, however, the hard reality can enforce solutions which really are minimal ones so far as additional margin is concerned.

An even better solution

The optical calculation program is provided with the aim of investigating if a biconvex lens relly has the optimum form. The result appears from figure 4 on the right. As figure 4 shows the radius of the light spot is 12,41 µm if the radius which is nearest the laser diode is 35,62 mm and the other radius is -11,57 mm. (The minus sign means that the centre of curvature lies to the left of the lens surface itself and the plus sign that it lies to the right). The lens then acquires the appearance in figure 5.

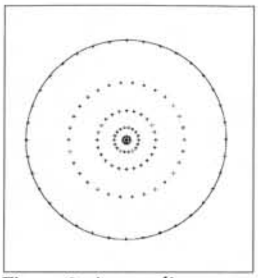


Figure 3. A spot diagram for a biconvex lens with focal length 18 mm and diameter 6 mm.

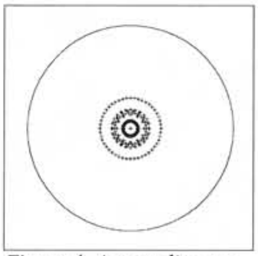


Figure 4. A spot diagram for the lens in figure 5.

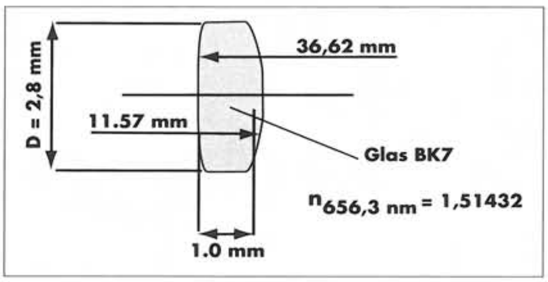


Figure 5. A biconvex lens with radii + 35,62 mm and -11,57 mm

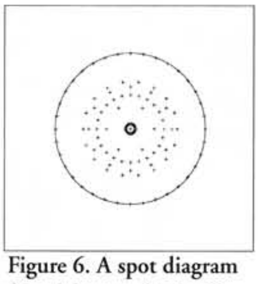


Figure 6. A spot diagram for a biconvex lens with the optimal opening 3,0 mm.

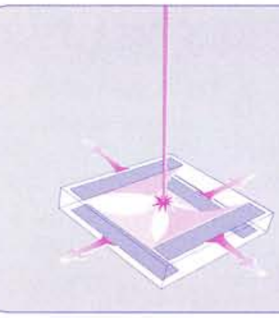
We must not forget that the radius of the Airy-disk is still 41 µm which also appears from figure 4. The reader may now be wondering what the purpose of the above-mentioned calculation is, since, after all, it is the size of the diffraction that determines the final diameter of the light spot.

Now, however, it so happens that the diffraction size depends on the diameter of the lens opening (See Non-Contact 1/96). We therefore almost double the lens opening from 2,4 to 4,44 mm and get the computer to calculate what is now happening. The computer has now calculated r1 at 36,28 mm and r2 at -11,65 mm while the Airy-disk radius has decreased to 20,36 µm as expected, but the geometric spot radius is 98,69 µm on account of the so-called opening error or spherical aberration as the error is also called.

This error depends on the fact that spherical lens surfaces are not at their very best when as sharp a focus as possible is called for. We therefore get the computer to calculate when the Airy-disk radius is as large as the geometric light spot radius, ie. we get the computer to work out the optimal opening. The result appears from illustration 6 and it is demonstrated that when the opening is 3,0 mm the Airy-disk radius is equivalent to the geometric light spot radius which is then 30,7 µm. This occurs when r1 = 35,80 mm and r2 = -11,59 mm. The illustration of the light spot's greatest extent, as a result of Gaussian magnification as well as diffraction, will be 30 + 2 x 30,7 µm = 91,4 µm. The entire lens opening will, nevertheless, not be filled by light from the laser diode since this, after all, only emits light below an angle of 7° at the minimum. This means that the diffraction will be somewhat larger than as we calculated above.

Before we leave our design that comprises a single lens, there is one other thing we must check and we shall do this in the next section of the PSD school.

Have we reached the end of the road or is there something else we can do so as to achieve an even smaller light spot? In the next section of the PSD school we shall look at how we can achieve an even smaller light spot through using a lens system that consists of 2 lenses.



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