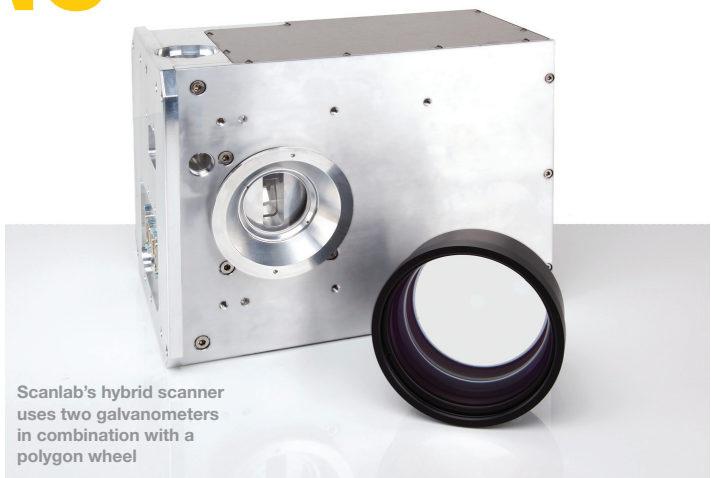
SCANNING NEW HORIZONS

Now that more ultrafast lasers are entering the market with pulse durations as short as pico- or femtoseconds, can the scanning technology to deliver the beam to the workpiece keep up? **Tom Eddershaw** finds out



Scanlab's hybrid scanner uses two galvanometers in combination with a polygon wheel

Scanlab

At Lasys 2014, a panel of experts identified the ultra-short pulse (USP) laser market as one of the most dynamic in the field of materials processing (see report on page 7). This type of laser is winning awards: the 2013 German Future Prize was awarded to scientists from Bosch, Trumpf, Jena University, and Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) for creating an effective series production tool.

These lasers are already an established source for processes such as cold ablation of material, but the manipulation and scanning of the beam has recently become an issue. At Lasys, questions were asked regarding the scanning system's ability to keep up with the increasing pulse rate. Visitors to the Stuttgart trade fair at the end of June were able to see a selection of new scanner systems, which are attempting to make the most of the potential of USP lasers.

With the advent of ultrafast lasers, a need for higher scan speeds has also arisen. The systems used to manipulate the lasers are typically galvanometer (galvo) scanners. However, Lars Penning, managing director of Next Scan Technology (NST), warned that it can prove hard to achieve micron accuracy with small spot sizes, when using a galvo at scanning speeds higher than 10m/s.

One alternative method does not use a set of galvo scanners, but instead polygon scanner technology. NST has used this technology to develop a system capable of moving the focused laser spot at speeds ranging from 7.5m/s to 100m/s and higher.

The polygon scanner uses a rotating multifaceted mirror that spins at a constant speed, scanning as the incident angle is changed, often with the workpiece moving through the scan line. The galvo uses manoeuvrable optics to manipulate the beam. Polygon scanners, which raster-scan the workpiece, can often process a material faster than the galvo systems, but offer less flexibility.

Penning said: 'At least 20 years ago in the graphic arts market they said that galvos were not the way to go, so high-throughput laser scanning moved into polygon scanning systems. This is what is now happening in material processing, but you have to justify the spending of money, and this can be a hurdle. The throughput needs to justify the investment.'

> **It can be hard to achieve micron accuracy when using a galvo at scanning speeds higher than 10m/s**

A polygon scanner is a one-line scanner that uses a stage or web feed to process a 2D surface. 'The drawback of this is that you have to scan the complete surface,' Penning stated. 'If you only need to mark on 1 per cent of the surface, the polygon scanner still has to cover the entire face which can add processing time. A galvo is very flexible, it is quite easy to move from one position to the next and you can manipulate the speed. For jobs on a large piece that need only a few or small marks, the galvos may be better suited.'

Polygon scanners are not a substitute for galvos, and they are appropriate for different applications. Penning said: 'If you want nice smooth curved lines which need little post production processing, which is often found when cutting glass, you benefit from galvos. Curved lines cut using a polygon scanner can cause a staircasing effect. This is due to the raster method used; each scan provides another step in the curve, but the final effect is not as smooth.' He gave the example of a smartphone screen: 'This requires a really high quality cut, and they use sapphire or Gorilla Glass. If the cut is made using a polygon scanner, the hole can show this staircasing at the curved edges.'

He continued: 'If the application only needs straight cutting, such as wafers, then it doesn't make much difference to the functionality of the piece which scanner is used, but the polygon type will operate quicker.'

He said: 'As ever, it depends on the application as to which one would be more suitable to a customer. It mostly depends on the fill rate of a material that need to be processed, if it's below 10-15 per cent the galvos may be more suitable. Some applications are not suited to polygon scanners, but those that are, such as 2.5D micromachining and high-density hole drilling, benefit hugely from them.'

Scanlab is currently testing what Dr Markus Zecherle, R&D manager research projects for the company, described as a first for the market: a hybrid system that uses both galvo and polygon scanning systems. Zecherle explained: 'The polygon is used for high speed deflection of the laser beam, which helps us achieve a greater line speed. The galvos correct for errors and also give us more freedom for positioning the laser.'

Since galvo motors only operate with a limited scan angle of less than 90°, the optics have to be accelerated and decelerated repeatedly. However, the lasers can only be used once the optics have attained the desired constant speed, as, during the acceleration phase, the laser pulses would be out of sync. The polygon scanners on the other hand do not need to be accelerated as they are constantly spinning.

Zecherle said: 'The polygon scanner is needed for the speeds but it isn't very flexible; you become fixed with a constant speed and if the workpiece becomes misaligned, the lack of flexibility can cause errors.' He went on to say that the galvos allow extra movement if the positioning of the workpiece is altered and the path of the beam needs to be changed.

Keeping cool

While in principle the system can be used for most laser types, there are features designed specifically for processing USP lasers. Zecherle said: 'The important point with USP lasers is that they are designed for very high accuracy applications.'

Cold ablation is one such task and part of the reason USPs are attracting attention. This process works by applying a laser pulse so quickly that heat energy is not transferred during the ablation process. This is particularly beneficial when processing certain materials that may be damaged easily by heat, such as glass for a smartphone screen.

Penning clarified: 'Incorrect distribution of the laser pulse results in thermal ablation and you lose the advantages of the ultrafast lasers.' Penning explained that this causes issues such as accumulation of energy which could damage the thermally sensitive piece. He continued: 'If you want to process a material using these lasers, you need to separate the pulses in a predetermined way that is aligned next to each other. However, if your laser has a repetition rate of 1MHz, a spot size of 50µm, and a scan rate of 10m/s then you might lose the benefit ultra-short pulses have to offer.'

NST was originally focused on the professional graphic arts laser printing market, before realising the need for rapid scan rates within material processing. Penning said: 'This knowledge has been transferred into our first product. We identified a need for greater scan speed, which came with the advent of USP lasers. These required a greater speed because of their performance and high rep rates.'

Successful scanning systems that can quickly and accurately deliver the pulses to the material are opening new markets for the photonics industry. Markets such as medical device manufacturing are only now being explored. Penning said this is happening because laser technology has reduced thermal effects. 'The absence of thermal effects mean a material can be machined without damaging the internal structure.'

Other areas are already making the most of the technology. Penning pointed to the number of silicon wafers being processed monthly to support the consumer market. 'Remember that each of them has to be diced, or cut beforehand. In Korea alone, they are processing two million wafers each month, and each of these components is getting smaller.'

He concluded: 'This also means the manufacturer will want to cut in a way that creates the smallest amount of waste. Mechanical processes are less suitable as they cause more waste or damage. With a laser, you can process the chips more efficiently than can be done mechanically.'