LASER + CAMERA = INNOVATION

Machine vision is making laser material processing even more flexible, accurate and cost-effective

The use of modern laser technology has become standard in industrial manufacturing thanks to its speed, accuracy and effectiveness. Lasers are used to engrave parts, electronic printed circuit boards or chip cards. They perforate packaging, structure semiconductor wafers, drill, cut and weld plastics or metals, and create highly complex structures via 3D printing – all contactless, with no application of force and wear-free.

Conventional systems for laser material processing require a large number of individual components and involve high integration costs in terms of mechanics and control software. Depending on the application, a system has to inspect the characteristics of each part even before laser processing begins. Following the laser process, an additional unit then inspects the quality.

The positioning of the parts in the laser system determines its accuracy to a large degree. Unfortunately, this positioning is extremely complicated from a mechanical point of view, as well as costly. If various types of parts are to be processed in a laser system, the laser system will need to be integrated into production control at a deep level.

RAYLASE AG has set itself the goal of making it easy for manufacturers, integrators, plant manufacturers, and researchers to take advantage of the powerful properties of lasers. The company offers high-precision components for fast deflection and modulation of laser beams, as well as functional assemblies and solutions for laser processing. One of its latest innovations has been to combine a laser deflection unit with industrial cameras and special machine vision software (see Figure 1).

Figure 1: On-axis machine vision control – combining a laser deflection unit with a camera coupled into the path of the laser beam

MODERN MACHINE VISION – UNIVERSAL, ACCURATE AND RELIABLE

RAYLASE has developed Machine Vision Control (MVC), which enhances conventional laser deflection units with the functions that are made possible by modern machine vision. Laser systems based on MVC can optically inspect parts, identify the type of each part, and allow parts to be placed in virtually any position in the laser field. This increases precision, speed and integration capabilities, while significantly reducing the costs associated with laser systems. In recent years, machine vision has established itself as an enabling technology in industrial manufacturing. High-precision quality inspection, contact-free measurement and process control based on optical image analysis make this technology ground-breaking in the area of manufacturing automation. The most frequently cited benefits are increased safety, traceability, the saving of materials and improved quality combined with greater resource efficiency and productivity.

In the laser process, optical measuring technology in conjunction with industrial cameras and software algorithms enable positioning and rotation of the laser relative to the part with micrometer precision. As a result, only a simple mechanism is required to place the parts in the laser field. The machine vision unit also offers native optical inspection of the quality of the parts. Geometric dimensions, color, texture, surface characteristics and overall appearance can be inspected in a direct variance analysis. RAYLASE MVC, combining laser technology with machine vision, is paving the way towards Industry 4.0, the basis for highly flexible manufacturing systems that can be configured entirely by software and can be operated more efficiently in terms of both time and costs while also ensuring improved production quality.

The camera, which is either integrated into the laser deflection unit or mounted on it, identifies the type, position and orientation of the part using object dimensions and markers or 2D data codes or lettering on the part. These characters are taught-in beforehand using the intuitive recognition tools of RAYLASE's weldMARK® Vision Software user interface.

The control software then selects the appropriate laser program for the part type identified. In this respect, the system therefore does not rely on integration with system control. Software algorithms adapt the laser process to the part's system of coordinates. With two mirrors controlled by galvanometers, the scanning head can direct the laser beam to any point on the part within its field of work. Once the process is completed, the software verifies that it has been successfully executed and documents the result. The MVC software offers a wide range of optical analysis options, while Click&Teach simplifies and accelerates the creation of a laser job to suit each new type of part.

THE EYE OF THE LASER

In the on-axis version of MVC, the camera is coupled into the optical path of the laser beam. This means that the laser and camera use the same scanning head mirrors to "look" at the object, as well as the same F-theta lens. As a result, this setup offers inherent compensation for temperature-dependent drift in the deflection unit, which causes deviations between the actual laser position and the position that is read. The on-axis technique enables particularly small working distances with the shortest focal lengths of less than 50 mm, while offering the highest levels of precision to less than 10 µm.

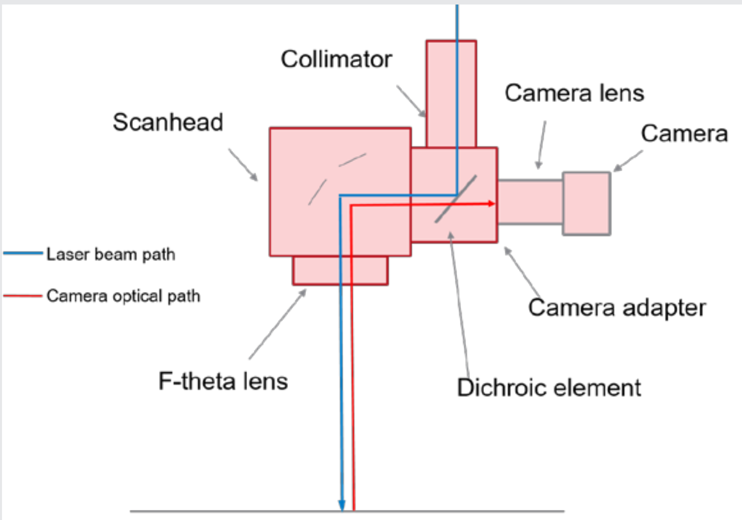

Figure 2: Schematic structure of on-axis machine vision control

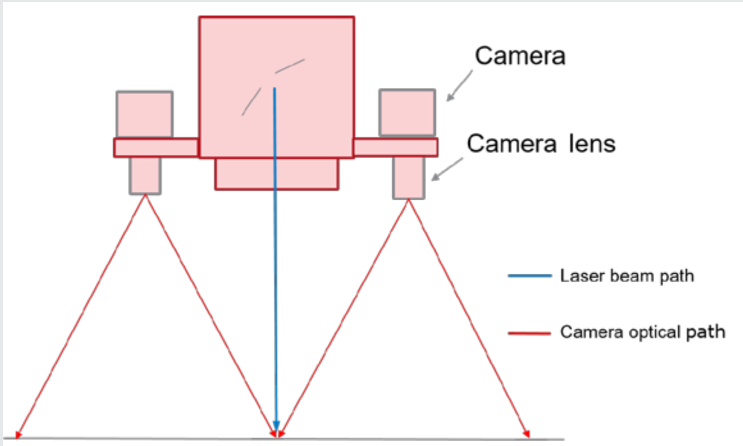

Figure 3: Schematic structure of off-axis machine vision control

The benefits offered by machine vision in terms of laser processes can also be exploited in "off-axis" applications, whereby one or more cameras (but usually not more than four) are installed outside of the deflection unit. This technology has benefits to offer, in particular in the case of "on-the-fly" applications, were the workpiece is constantly moving throughout processing or where large parts of the workpiece need to be captured quickly.

INDUSTRIAL APPLICATIONS OF MACHINE VISION CONTROL

The integration of machine vision and laser systems increases efficiency and cost effectiveness in many manufacturing processes across a wide range of industries. Applications such as perforation in the packaging industry, laser cutting in the textile industry, laser welding and deep engraving in the automotive industry, and ITO patterning in the electronics sector all benefit from the high degree of precision offered by contact-free laser processing.

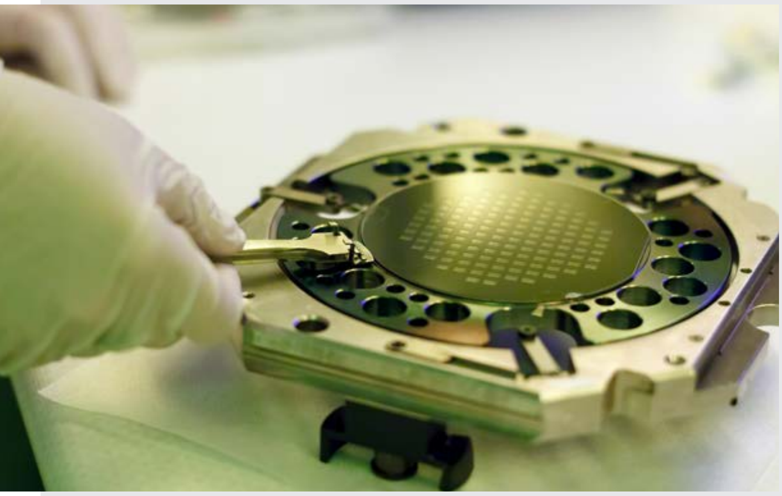

Figure 4: Elaborate holding device for the handling of semiconductor wafers

In the microchip industry, sensitive wafer plates are laser-etched along their crystal planes. Every single wafer has to be analyzed prior to the laser process. If the inspection is successful, the MVC adjusts the laser process to the exact position of the wafer and the orientation of the silicon crystal planes, with tolerances of just a few micrometers. The detection of position and orientation, as well as the subsequent quality assurance via MVC eliminate the costs associated with high-precision mechanical wafer positioning. This not only simplifies the mechanical construction process but also protects the very sensitive wafers from mechanical damage by positioning equipment.

In the manufacturing of solar cells, the energy-absorbing photovoltaic panels are put together from the sensitive crystalline wafer plates. The optimal design requires, above all, that the wafers be welded together with precision. Before laser processing begins, RAYLASE MVC uses machine vision technology to detect the position of the plates that are to be welded together, and reliably adjusts the starting coordinates and orientation of the laser job.

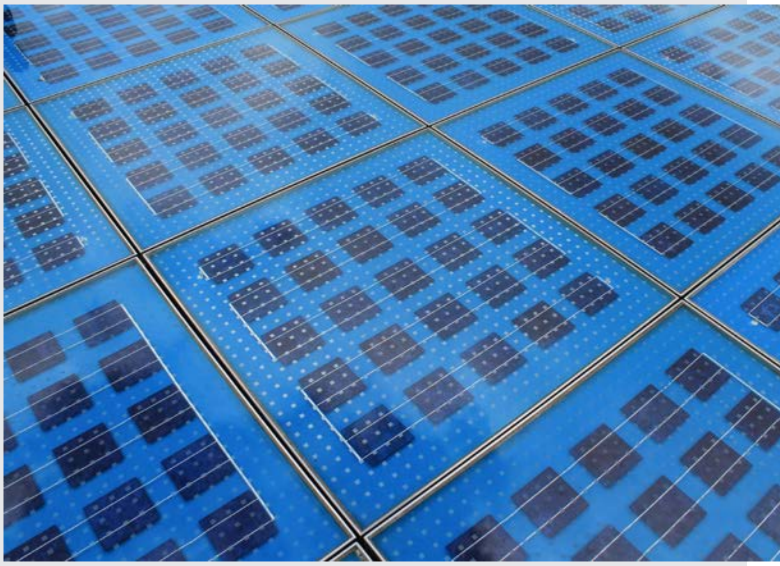

Figure 5: Individual solar panels must be welded together with precision

Conductivity is also an important criterion in the automotive industry with its innovative eMobility concepts. For a wide range of modern electric cars, the cell packs of lithium batteries are welded together using cell binders to maximize the energy output of the series-connected cells. One challenge that presents itself here is that the laser welding systems have to deal with many different types of battery. With RAYLASE Machine Vision Control, the Click&Teach function allows the process engineer to quickly and easily prepare the laser welding system for new battery types.

In addition, the process engineer can use the graphical user interface of the weldMARK® Vision Software from RAYLASE to mark characteristic features in the live camera image, which MVC can use to identify the position and orientation of the battery. The "Click&Teach" function can then be accessed from the GUI to define the laser process. The MVC software takes care of the rest.

Also in automotive manufacturing, laser welding technology has been used for some time now to insert the glass panel on dashboards. MVC image analysis is also used in this case to ensure high-precision positioning of the weldseams based on the characteristics of the dashboard housing.

Figure 6 The glass covers of dashboards need to be welded with precision (position of the weldseam shown in red)

Using machine vision technology allows laser tasks to be executed with the highest degree of precision in extremely challenging industry applications. In medical technology, for example, MVC can be applied in the manufacturing of blood glucose test strips. On these strips, wafer-thin capillary channels carry the patient's blood to the measuring sensor. For this application, laser systems must cut the test strips out of PET plastic "sandwiches" along printed contour lines with an accuracy of below 50 µm. Machine Vision Control detects the characteristic properties of the sandwiches, and automatically positions the laser job for an exact cutting process without destroying the wafer-thin capillaries.

Figure 7: The delicate capillary channels of the blood glucose test strip serve to transport the blood to the sensor

SUMMARY

The Machine Vision Control (MVC) system from RAYLASE offers a combination of machine vision and laser technology in the form of an all-in-one solution that simplifies process steps while simultaneously reducing integration costs and increasing precision. To ensure easy implementation, a detailed analysis of the application conditions must be carried out by experts in advance. The individual system configuration, comprising lasers, cameras, lenses, lighting and the choice of the best deflection system are subject to precise specifications and require substantial experience with laser and machine vision systems. The interplay of the individual components produces optimal results, and the highly configurable MVC can be easily integrated into a larger network of systems. RAYLASE is pioneering in its combination of laser deflection technology with machine vision. Based on many years of project experience, the company also offers customer-specific consulting for a wide range of industries and applications. In this way, machine vision control and RAYLASE's development expertise guarantee a fast time-to-market while also minimizing project risk.