4SURfaces

Issue 4

The Laser Technology Magazine by 4JET

CUTTING EDGE

Laser Cutting of Glass

LASERS ROUND UP

Tomorrow's Tire Technology

LASER | SYSTEME | SERVICES

4JET

Editorial

People have been using glass as a material for nearly 4000 years. And yet we are still constantly discovering new applications for using and processing different types of glass.

One of the drivers behind this progress is the increasing use of touch panels in smartphones, tablets and other hand-held appliances, or as a control panel in automotive, industrial and household applications. The challenge facing design engineers is to make glass components thinner, but at the same time sturdier and cheaper, or to use the rigid material to form three-dimensional or flexible displays.

Producing such components to accurate dimensions and in large quantities is the perfect task for lasers, which can handle just about any challenge. Focused light can be used to create complex bore holes, to cleanly cut strengthened glass, or to modify or ablate functional layers on glass. Lasers can join glass, polish edges, and mark components. And every time a new application for glass is dreamed up, it signals the next opportunity for laser technology.

Looking ahead to the future of 4JET, we want to develop these themes into a core area of our business to enable us to tap another promising market alongside our established competence in the automotive and photovoltaics sectors. Despite – or precisely because of – the fact that glass is really nothing new ...

Warmest regards

Dr. Uwe Stute
VP Glass Technology + New Materials

Imprint

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4JET Traces

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Content

EXACT

Microprocessing with the Lablator

The new LABLATOR HP is a flexible system platform developed by 4JET for microprocessing in industrial and research applications.

The basic module comprises a high-precision axis system with nonferrous drives, mounted on a granite table. It can move at speeds of 2 m/s with accuracy levels of better than 10 µm.

Component jigs or lenses can be mounted on the portal to enable both moving and fixed beam paths.

An optical table attached to the system permits flexible arrangement of several laser sources and beam delivery and shaping components.

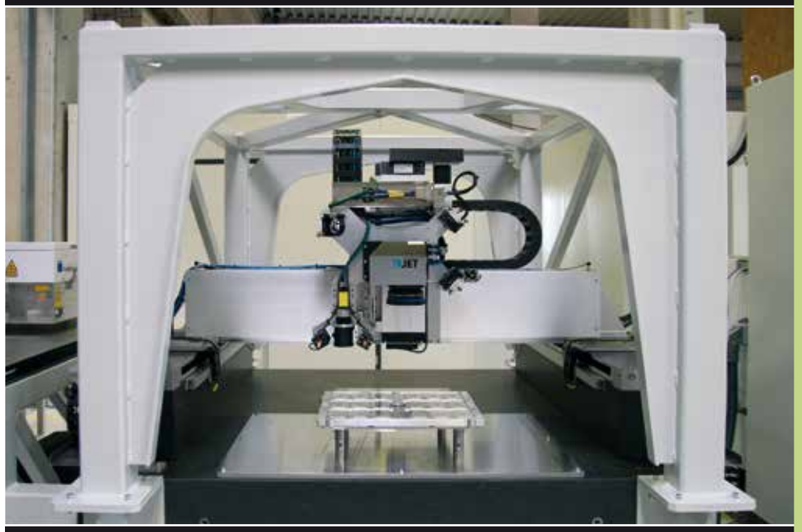
Infinite scan field
The travel paths of the axis system can be programmed precisely on the machine control unit, while the software program can import CAD data for easy conversion into G code.

If the appropriate scanner is used, the moving axes of the portals and the scanners can be interpolated, thus creating a virtually unlimited work area spanning the entire travel path of the portal, and permitting precision spotting of the laser pulses. As a result, displays that are larger than typical scan fields can be patterned, for example.

The use of a special drill engine permits creation of free-form drill holes with optional chamfers.

The system can be loaded automatically, or manually by the operator, depending on the application.

The areas to be processed are aligned on the substrate using a vision system that detects edges or position marks.

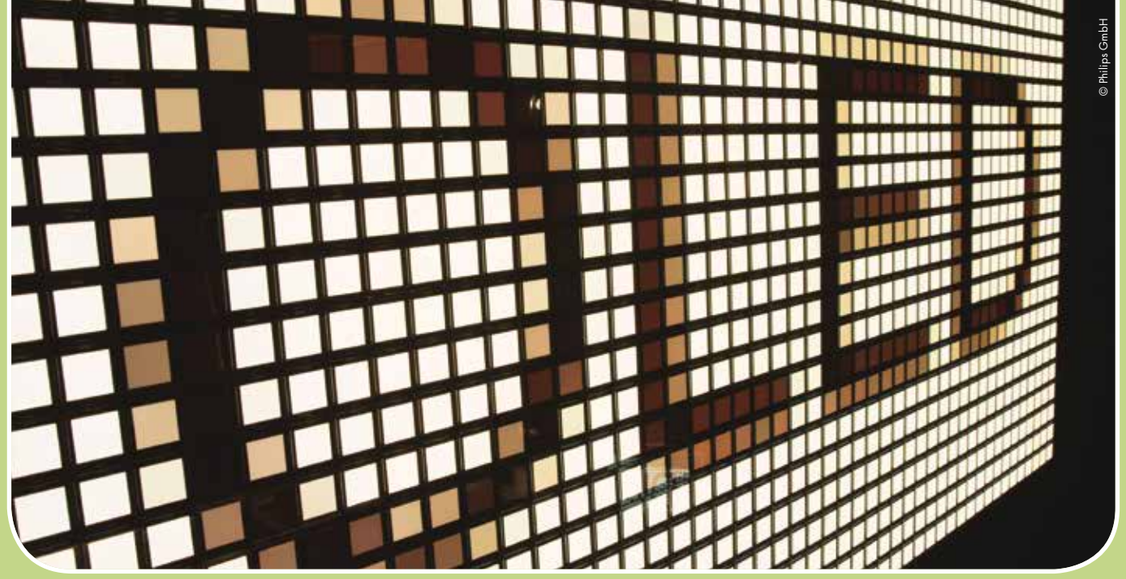


Flexible modular system
The new platform can be enhanced with optional containers for working in controlled atmospheres, vacuums or liquids, and with transportation modules for flexible sheet material.

Numerous large sliding doors, LED surface area lighting and a separately movable operating terminal make the system user-friendly to setup and operate.

On request, 4JET can supply the systems complete with laser processes, for structuring and modifying thin layers, or 3-D processing of glass substrates, for example.

Industry and research
The first systems 4JET has installed are as diverse as the possible system configurations. Customers include both a manufacturer of electronic components, and a research institute focusing on renewable energies.



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SLAM – *Individual OLEDs*

4JET has developed a completely new laser procedure in collaboration with NOVALED AG (Dresden) for individualizing and optimizing organic LEDs.

The procedure enables individual processing and darkening (so-called "gray scaling") of finalized and encapsulated standard OLEDs. The density of the OLED light can also be optimized. The procedure is also suitable, in principle, for insulating short circuits.

The new SLAM (**S**elective **La**yer **M**odification) procedure therefore enables OLED signage applications for batch sizes of 1 or more and the creation of individual logos or structures. The ultrashort laser pulses are so gentle on the material that the processed areas are not visible when the light is switched off.

The flexible processing of the sensitive layer systems is performed without the use of elaborate lithography processes on the finished OLEDs. This means that, for the first time, signage applications can be tailored to customer requirements even after production.

4JET and NOVALED are marketing the SLAM process together, whereby 4JET offers both fully integrated laser systems and OLED processing as a service.

The joint invention is patent pending.

OLED – may I introduce myself?
OLEDs (organic light emitting diodes) are semiconductors made of layers of organic material that are just a few nanometers thick. They emit homogeneous wide-area light. This ground-breaking technology constitutes a whole new approach for architects, designers, system integrators, planners and light manufacturers when dealing with the issue of light.

Organic LEDs are heralding a new light age. They allow completely novel applications combining shapes and colors to integrate light into living and working environments in a way that is totally new. OLEDs are energy efficient, made of environmentally compatible materials and require little effort to integrate them into a system. The lights therefore make a sustainable contribution to protecting the environment.

Looking ahead, OLEDs will make it possible to manufacture gossamer-thin, transparent, flexible, high efficiency displays with brilliant colors and high levels of contrast. They are currently used in PDA, camera, cellphone and MP3 player displays.

novaled

© NOVALED AG

GLASS

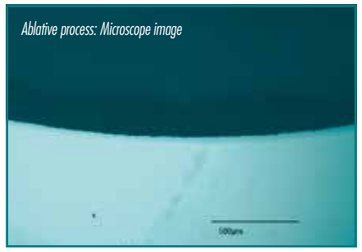
Glass has been giving us pleasure for ages – in church windows, jewelry or wine glasses, for example. Many items used to be hand-crafted or the glass meticulously blown into shape in the past. Nowadays, glass is not only omnipresent on building facades; it is also a key element in mobile electronics, for which it is manufactured, processed and finished on an industrial scale. This progress is opening up opportunities for laser technology since automation increases as production volumes grow. Lasers can apply targeted heat and can therefore be used to cut, drill or re-shape.

Ancient material with a promising future

Display Glass

In the visible light spectrum, pure glass is transparent, chemically resistant, and very hard. Processing options can even enhance these positive characteristics additionally on modern products. Single-pane safety glass or display glass, for example, can be heat or chemically strengthened to make it even harder and thus better able to resist impacts, knocks and scratches. To achieve this, compressive stress is applied in the area close to the surface. For heat strengthened glass, this process involves heating the area to above its transformation temperature and then rapidly cooling it. In the case of chemically strengthened glass, sodium ions are replaced with larger potassium ions in order to create the compressive stress zone. These chemically strengthened types of glass are key components in the display industry. After all, users measure the value of their cellphone or tablet PC by its suitability for safe everyday use. Appliances must be capable of withstanding many a jolt or acid attack from spilled liquid, yet still continue to reflect brilliantly the light from the display. In recent years, the dynamic development of the market following the launch of iPad & Co has been almost unbelievable. If production is to keep pace, automation is the only answer. Automated production lines can produce large-scale glass formats (e. g., Gen 4.5 measuring 730 mm x 920 mm edge to edge), which can then be separated or cut directly to the required shape. Cutouts for microphones or cameras have to be drilled or cut with narrow radii. Lasers are perfect for this task, as they can work without touching the material or applying force, and they are precise and very fast.

In addition to its foremost positive characteristics, however, glass does pose some processing challenges. Since glass is brittle, stress and cracks can cause it to fail, especially when exposed to tensile stress. Since lasers cut or drill at high temperatures, the process must be carefully selected and implemented to avoid generating unwanted



Ablative process: Microscope image

stress during the machining procedure. In recent years, advances in laser technology have enabled the shortest time scales for beam impact to specifically crack the material, vaporize it and even create a plasma. These (ultra)short pulse lasers emit pulses ranging from a few hundred femtoseconds (1 fs = 10^{-15} s) to a few nanoseconds (1 ns = 10^{-9} s). These lasers, which are now available for industrial applications, work in the near infrared (λ ~ 1 µm) or green (λ ~ 515–532 nm) ranges. When drilling or ablating, the beam is strongly focused onto a very tightly defined area where the material is vaporized at high temperatures. Basically, the shorter the pulse, the smaller is the range outside the interaction zone where the glass reaches temperatures that can be critical for stress. Compared to iron, the heat conductivity of glass is only 1 - 1.8 %. Given this low conductivity, the heat generated during these pulses can only penetrate a few micrometers into the material. As such, ultrashort pulses only apply minor stress to the edge zone during machining. The ensuing stress causes minor chipping. In drilling procedures, such as illustrated on this page, it has been possible to reduce chipping to less than 5 µm, which is compliant with customer requirements. Drilling and ablating enables the creation of the smallest holes and radii, and thus virtually any conceivable geometry. Ablation is hugely superior to any other procedures in this respect.

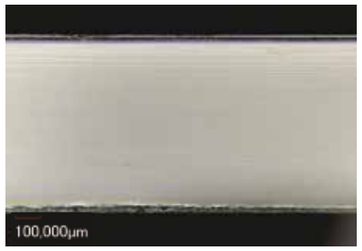
In addition to ablative procedures, processes that are more energy efficient are currently being used to create specific cracks. During ablation, the kerf must be vaporized. As volumes grow, the cycle times involved are no longer compliant with customer requirements. One means of reducing energy is to specifically create a crack. This can be achieved using high intensities where (ultra)short pulses using low pulse energy briefly exceed the critical temperatures for creating stress but remain beneath the smelting temperature as a rule. Using a suitable process strategy, these microcracks can join to create a crack along the laser path. This specific cracking procedure can be used to create gap-free straight and curved cuts in the millimeter range. The validated cutting speeds are in the range of > 700mm/s, thus permitting contour cuts.

more on page 8

Ablative process: Microphone slot

In addition to applications in the display industry, lasers can potentially be put to good use wherever brief local heat can save energy by eliminating the need to bring glass tubes or sheets up to high temperatures. Furnaces and burners can therefore be replaced with rapid control high-performance lasers. Applications include joining procedures or improving the electro-optical properties of coatings.

4JET is aiming to tap the huge potential offered by laser-based glass processing through its new business unit "Glass Technology + New Materials", which bundles all of the necessary market and material expertise.



Contour cut with 20 µm bevel

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Dr. Uwe Stute studied physics at the "Carl von Ossietzky University of Oldenburg" and received his PhD at the University of Rennes. He then worked at Laserzentrum Hannover (LZH), where he took over the department for "Production + Systems".

In 2007, Dr. Stute started working in innovation management at TRUMPF Laser GmbH + Co. KG, where he was in charge of product and application management for micro-technology with a focus on photovoltaic and high power short pulse lasers.

In April 2010, he returned to the LZH, where he became head of a department incorporating laser applications in the areas of glass, photovoltaics and carbon reinforced plastics and two groups dedicated to micro- and system technology.

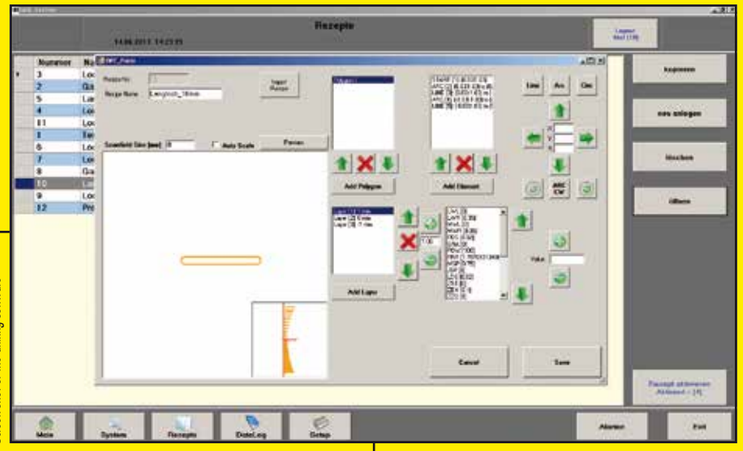
In May 2013 Dr. Stute took over the management of the new business unit "Glass Technology + New Materials" at 4JET.

LASER DRILLING
with the 4JET Drill Engine

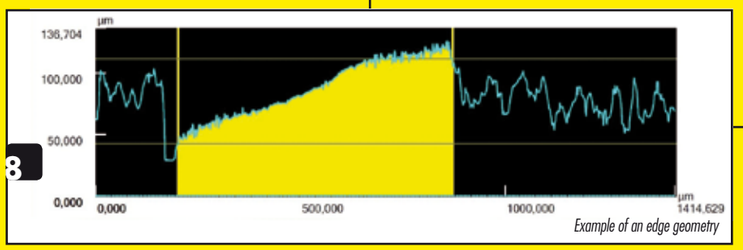
4JET has developed a flexible solution for laser drilling into glass, which uses short pulse or ultrashort pulse lasers, depending on the specified edge quality. Chipping ranges from less than 100 µm to less than 10 µm, depending on the selected procedure.

High performance software offers not only a choice of drill shape (e. g., circle, ellipse, triangle) and width of the free cut, it also permits the creation of specific edge geometries. For example, bevels can be created in display glass that is thinner than 1 mm – even in the compressive stress zones produced during chemical strenghening. The glass is processed from one side with a single laser module and without the need to turn the substrates.

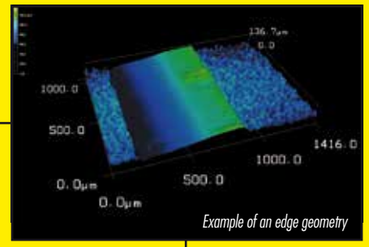
4JET integrates the drill module for free forms in different system platforms, such as the GDS modules used for solar and architecture glass, or the high-precision Lablator platform for processing display glass and OLED substrates (see page 5).



Screen shot of the drilling software



Example of an edge geometry



Example of an edge geometry

AN *award-winning* IDEA

4JET Alsdorf is a "Selected Landmark" in the Land of Ideas

Germany Land of Ideas – Selected Landmark 2012


The project team was presented with the winners' trophy and much appreciated the applause of all guests and colleagues.

"Modern electronics thanks to laser technology" is the name of the project that won 4JET the accolade as one of 365 "Selected Landmarks" in the Land of Ideas. The competition is organized by the initiative "Germany – Land of Ideas" in collaboration with Deutsche Bank and each year recognizes 365 outstanding projects and ideas that make a lasting contribution to Germany's sustainability. As an award-winner, 4JET becomes an Ambassador for the Land of Ideas and embodies the innovative potential of Germany.

The winning project

The manufacture of flexible electronic components requires the structuring of conductive layers on plastic films. Lasers are ideal for the task, as they can ablate thin layers with enormous precision. The technology is used in the production of flexible solar cells, particularly lightweight touch panel displays, and in organic electronics.

Award ceremony for the project team

The award gave 4JET just the excuse it needed to organize a summer party for friends, partners, staff and their families. 4JET was proud to welcome guests of honor, including Alfred Sonders, Mayor of Alsdorf, and Helmut Brandt, Member of the German Parliament (Bundestag).

The award ceremony was followed by some culinary delights, sports and a look at day-to-day working life at 4JET. Guests were able to visit various technology stands to watch laser technology for mold cleaning or glass processing in practice, and to gain insight into 4JET's analytics lab.

During a festive reception in the State Chancellery, Minister for Innovation, Science and Research in the State of North Rhine-Westphalia Svenja Schulze presented the official Honors Board to founder and CEO Jörg Jetter.

© Germany - Land of Ideas/Uwe Völkner, Fotoagentur FOX

4JET EXPANDS *A smart solution*

4JET now has more room for staff offices and meeting rooms in Alsdorf. Office space was built for 30 staff members in the immediate vicinity of the main building in just a few months.

Since starting business in 2006, 4JET has grown continuously. In 2009, company headquarters were moved from Hückelhoven to a larger building in Alsdorf. Now, a new extension has been built to house additional workplaces.

The company opted for Smart House, an innovative, high-quality construction concept using pavilion modules made of natural building materials.

The modular concept minimizes construction time. In just three days the modules are delivered on flatbed trucks, set up and joined, and the air conditioning and sanitary systems are connected. Furnishing the turnkey smart house was the last step prior to opening the new office space. It took less than two weeks from delivery of the modules to moving in.

One key advantage of the smart house concept is the option to add on further modules. So there is nothing to stop 4JET growing even more in Alsdorf in future.

ON THE ROAD TO SUCCESS

MIXEDzone

GO WEST

Sales office in the USA

4JET is also expanding its business in the Americas, and is increasing its distribution setup in North America by opening a subsidiary that is being coordinated by General Manager Rolf van de Velde. This marks another step in expanding the sales network of the 4JET product lines for the photovoltaics, glass and tire industries.

The company – called 4JET Americas LLC – is based in Chatsworth near Los Angeles in sunny California.

Rolf van de Velde has experience in capital equipment sales to high-tech industries for many years. Born in the Netherlands, he has been living in the USA for more than ten years.

WINTER PLEASURE

4JET on Tour

After a year characterized by hard work and major successes, the 4JET Team ascended to even greater heights – up the mountains.

Loaded onto a bus and full of cheer, the group headed off to Saalbach Hinterglemm, one of Austria's loveliest ski regions. Everyone – piste experts, beginners, snowboarders, tobogganists, cross country skiers and hikers alike – enjoyed themselves and had a great time!

ON THE ROAD *Tire Technology Tour*

4JET is heading off on a roadshow around Europe to demonstrate its laser systems for cleaning tire molds and marking tires – all "live" in the production facilities of leading tire manufacturers.

As Florian Schreiber, Key Account Manager for the tire industry at 4JET, explains: "The Tire Technology Roadshow allows us to present our high-tech developments on site to leading tire manufacturers throughout Europe".

4JET has packed an STMCS – its fully automated laser mold cleaning system – on a flat bed truck. Using lasers to clean molds offers advantages over other procedures, such as dry ice, in that the process damages neither the tire molds nor the venting systems, and is a dry procedure. Added to which, the virtually silent machines emit little CO_2 and are therefore particularly environmentally friendly. A typical tire mold can be cleaned in less than 30 minutes with minimum energy consumption.

4JET has also packed the T-Mark Compact – its hand-held tire marking system. It lasers serial numbers, bitmap files with customer-specific logos, or barcodes onto tire surfaces, and thus allows the entire life history of each marked tire to be traced.

Read more about 4JET laser systems for the tire industry on the following pages.

Dates for the Tire Technology Roadshow can be booked with Judith Harhues (sales@4jet.de).

New applications for Tire Marking

The mobile laser engraver T-Mark Compact for engraving of bitmaps or serial numbers is being used all over the world to mark tires individually. The most recent application is in the classic tire industries, where companies engrave whitewall tires for classic cars not only to comply with legal requirements but also to customize tires with logos or customer names.

The company is a fourth generation family business which has grown from a tire retread manufacturer to a premier whitewall tire producer for classic cars. Bill Chapman, the founder of Diamond Back Classic Tires (DB Tires) transformed the company after working with his father in the retread business. Now his sons and daughters carry on the business built on the values of respect and courtesy.

Apart from white sidewalls, the company also produces redline, blueline and goldline tires. The plant is located in Conway, South Carolina. Diamond Back Classic Tires vulcanizes custom sidewall treatment to any modern day radial tires, coming from Michelin, Firestone, Goodyear and many others. Tire sizes range from 13 to 22 inches.

The white compound is being applied to the finished tires. First of all, the sidewall surface is being roughened. Then a special bonding agent is being applied to prepare the tire for the vulcanization process. In a completely automated process, the white rubber is mounted onto the surface. In the now following vulcanization process, the rubber layers are bonded to the tire sidewall permanently. The last step is the trimming of the materials to the ordered width.

At DB Tires, the whitewall material is made up out of three layers, which guarantees that the whitewalls do not turn yellow over the years. The bottom layer is black rubber, which is also being used in truck tire retreads. It guarantees the adhesion to the tire's sidewall. The second layer is a butyl barrier layer, which prevents black rubber chemicals from coming through to the surface. The last layer is the white surface layer. The formula for this white sidewall rubber is the company's best guarded secret.

After applying the white sidewall treatment, Diamond Back Classic Tires is obliged by US federal law to equip the tire with certain legal information, such as the tire size and production week (DOT Code). The company uses the mobile T-Mark Compact to engrave on the whitewall all the necessary information. Through the engraving of logos or customer's names and pictures, a further customization of the tire is possible.

LASER *for a nice round finish*

Driven by ever-increasing quality demands, laser technology has become a firm fixture in the tire industry. Since starting business in 2006, 4JET has supplied nearly 100 laser systems to tire manufacturers in more than 25 countries. Here are some examples of what they can do:

Laser cleaning produces perfect tire surfaces

Tire molds require regular cleaning – after every 1000 - 3000 or so tires – to remove production residue and guarantee consistent product quality and an attractive appearance. Depending on the product and batch size, the steel and aluminum molds either have to be cleaned, together with their side skins, in the tire press, or are removed for cleaning. Cleaning the profile fins and vent holes presents particular challenges.

Pulsed solid-state lasers are particularly good for this cleaning procedure. The pulsed light peaks at up to several million watts when it meets the soiled surface. The instantaneous application means that the energy cannot dissipate, and it virtually blasts the unwanted matter off in a small area. The impact area is the same size as the area covered by the laser beam spot on the surface. By repeating this process and forming a row of individual beam spots, the surface can be gradually cleaned pulse by pulse.

The matter that is blasted off – generally fine dust and gas – is suctioned off locally and evacuated to a filter. During the short pulse duration, the substrate absorbs virtually no laser light. As a result, if processed properly, the molds suffer no mechanical, chemical or thermal damage.

In addition to cleaning without damaging the material, lasers are also convincingly low cost to operate. The variable cost of cleaning a mold is less than 3 EUR, whereas the alternative procedure using dry ice would incur costs of more than 20 EUR in compressed air and ice pellets.

Laser marking for 100 % traceability

Tire sidewalls bear a whole host of logos, numbers and codes. Much of this information is unalterable, which is why it is engraved into the vulcanizing molds used to cure the tires.

Some of the data is, however, alterable, such as production data, manufacturing plant, country registrations, or special marks for OEM customers. When completely retreading truck tires, the entire history of the tire is traced on the new sidewalls.

In the past, stamps mounted in the molds were used to imprint such information on the tires. Every time the information changes the stamps in the mold have to be swapped accordingly. Added to which, they actually have to be manufactured and distributed among the molds in use, which is a logistical nightmare for a modern tire plant that produces as many as 70,000 tires a day, and results in numerous errors and high costs.

By contrast, laser marking is a fast, attractive, forgery-proof and durable means of marking tires after production. ASCII codes and logos can be modified by software and applied. The laser beam applies energy locally that vaporizes the tire rubber and leaves a fine groove in the sidewall. As such, the marks are sunk into the tire and protected against ablation.

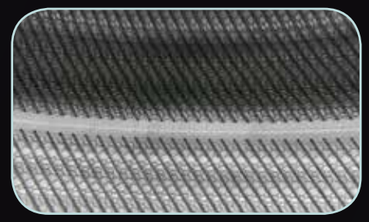
4JET has developed two system concepts for this process. Fully automated T-Mark systems permit automatic positioning, position detection and marking of tire sidewalls for batch sizes of 1 or more. The tires are centered, optically measured, and the marks engraved exactly on the specified target area. T-Mark Compact is a hand-held marking system that was developed especially for use on complete retreads or for marking test tires in warehouses. The system can be applied without pressure to the sidewall and engraves the entered data at the push of a button (see also our user's report on page 13).

Secure grip thanks to glue preparation

Preparing the inner surfaces of a tire for downstream gluing processes is another area where laser technology can be used. Residues of oily release agents need to be removed and the smooth surfaces roughened to guarantee a secure bond, for example with foamed polymers.

Instead of the work-intensive and environmentally harmful use of wet chemical cleaning systems, the use of pulsed lasers permits dry and precise cleaning of the tires. The beam guide developed by 4JET for mold cleaning makes it easy to program the areas to be cleaned, and to avoid shadows.

Depending on the selected energy density, the surface is either just cleaned, or also specifically activated. With the



use of solid-state lasers operating in a range of several hundred watts, cycle times of less than 1 minute are possible.

Module system for higher quality

4JET uses standardized material handling, beam guide, automation and suction components for the various applications. This modular system technology guarantees short project delivery times and high levels of availability in shift operation. New laser applications for tires can be implemented quickly and safely.

LASER | SYSTEME | SERVICES

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