AKL'12 and Innovation Award Laser Technology 2012

More than 600 international participants attended this year's International Laser Technology Congress AKL'12 in Aachen

The Innovation Award Laser Technology is a European research prize awarded biannually by the association Arbeitskreis Lasertechnik e.V. and the European Laser Institute ELI at the AKL laser conference. The aim of the award is to honor an individual researcher or a project group for their achievements in the field of laser technology. The project must focus on laser materials processing or methods of producing laser light and yield a commercial value. The award includes a prize money worth 10,000 Euro as well as the titles "AKL Fellow" and "ELI Fellow".

AKL e. V. president U. Berners (left) and vice-president R. Poprawe (2nd from right) present the award certificates to R. Pätzel, M. Kogel-Hollacher and S. Brüning. (Image: Wiley-VCH)

The academy award-like ceremony was held at the eve of the laser congress in Aachen's historic city hall. There was not too much time for celebrations, though: Reinhart Poprawe, director of the Fraunhofer ILT and RWTH professor for laser technology, reminded the guests to be right on time for the congress opening early next morning.

After two days of three parallel sessions at Eurogress Aachen and many live demos at the ILT, Poprawe concluded: "AKL'12 was very successful. Besides the quantitative records in terms of participants, sponsors and speakers the quality of the lectures was excellent. Innovative developments in companies and research centers that are of relevance for macro- and micro-processing in laser applications make the nucleus of AKL."

With the addtional Laser's ABC workshop, the EU-forums and the Technology Business Day focusing on laser markets in Europe, USA and China, the AKL proved to be a valuable networking platform for laser manufacturers and laser users.

3D Micro-structuring of Large Scale Metal Surfaces for Embossing and Printing Applications

Interview with Dr. Stephan Brüning (Schepers GmbH & Co KG, Vreden, Germany)

Stephan Brüning and his multi-company/institute team is the 1st prize winner of the Innovation Award 2012 for their innovation "3D micro-structuring of large scale metal surfaces for embossing and printing applications with high power ultrashort pulse-lasers".

LTJ: ***You are accepting the award for the entire PIKOFLAT team. What where the main goals of this project?***

Brüning: Coming from the graphics industry, we manufacture systems for engraving metal cylinder surfaces and are more in the tradition of lithography where you have an etch-stop-mask process, which means surface-coating and transfer a bit map file with a laser, and subsequently etch it. We wanted to replace this process by a one-step laser procedure with a picosecond laser. An important point here is power per unit area, i.e. ablation rates. Although, with currently 20 mm^3/min, our ablation rate does not reach that of lithography, that is the direction we are aiming at and where we show the potential. Another goal, compared to lithography, because this technology is state of the art, is to achieve higher resolution. In addition, we wanted to achieve seamless 3D structuring. In lithography, you have the problem of having to operate in 20 or 25 steps but we wanted to be able to produce a continuous 3D shape. In addition, our process does without environmentally risky etching.

LTJ: ***What companies and institutes contributed with which know-how?***

Brüning: The PIKOFLAT project was partly funded by the BMBF within the frame program MABRILAS. Fraunhofer ILT was project coordinator and conducted some of the scientific work regarding ablation with ultra-short pulse lasers as well as the development of the actual laser equipment. Then, of course, we had the industrial partners. Lumera developed and built the oscillator for the project, EdgeWave focused on amplification. We, Schepers, integrated the laser into our systems and Saueressig is the end user deploying our equipment for structuring their printing rollers. One other partner who did not have anything to do with roller engraving was part of the team – Sauer Lasertec took care of 3D-free-form processing. So the project was divided into two branches: our part in cylinder processing and the part of 3D-free-form processing.

LTJ: ***Past July, you had already presented interim results ("Kleinste Strukturen auf großen Flächen", LTJ 8 (4), 2011, 24–27). At the time, your 3.3 MHz laser had reached a***

power of 100 W. To what extent were you able to improve these values?

Brüning: The last demonstrator had a mean power of 400 W and pulse frequency of 10 MHz. This enabled us to raise the ablation rate to the desired 20 mm^3/min. Even higher rates were possible but you always need to find a compromise between ablation rate and quality. Of course, you could increase ablation even further but then you don't get the quality desired. You always have to consider the balance for the production case.

LTJ: ***To date, what is a typical value for ablation rates achieved?***

Brüning: Before starting the project, we had ablation rates of approximately 1 mm^3/min with a 20-W laser. Then, during the project, our 75-W demonstrator featured 3 to 4 mm^3/min, and now the next step is to aim for 20 mm^3/min. For comparison: our nanosecond laser ablates up to 300 mm^3/min. Of course, this is a giant gap but then you cannot compare the resulting quality. If the high quality is not needed for a certain application then you can go with the high-rate process.

LTJ: ***Probably any project tries to develop a laser with higher power. To what degree did your project require special research and development in beam sources? Is this a niche application?***

Brüning: The special part in our project was scanning technology. High average powers can be achieved only in a process where quick beam deflection and correspondingly fast rotating workpieces come together. We started out from a workpiece rotating at high speed (up to 40 m/s), and then discovered that we could increase the pulse rate to 10 MHz. Then we developed a scanning technology from the fast laser and our fast workpiece. Surely, this is not a niche thing. Quick scanning technology is needed for other applications as well in order to get the most out of fast lasers.

LTJ: ***For rollers the operating principle of the scanner is comprehensible. But how does it work on flat sheets?***

Brüning: Initially, we had thought about using a polygon scanner to sweep across the complete roller axis. However, expenditure for installing such technology would have been huge. So we worked on finding a way to deploy our setup as it was. We simply installed a small scanning axis responsible only for adjusting the pulse distance, which brought us to a deflector with a scanning length of several 100 µm. Nothing more is needed because this is the fast axis for adjusting the pulse-to-pulse distance. The other axes are then only required for positioning tasks and thus can be two orders of magnitude smaller.

Winner Stephan Brüning shows the structured embossing roller.
(Image: O. Dreissigacker, Wiley-VCH)

LTJ: ***What spatial resolution does the method yield?***

Brüning: We obtained a lateral resolution of up to one micron. We are using a spindle system and the motion of the ball spindle is controlled with a glass scale. The manufacturer of the glass scale specifies a line-to-line accuracy of 300 nm, so 1 µm — what corresponds to 25,400 dpi — is well within reach. Besides we reached a smallest lateral resolution of 2 µm with an ablation depth per pulse of some tens of nanometers. In the layer based structruring it results in a depth resultion of approx. 200 nm per layer.

LTJ: ***What are such high resolutions needed for?***

Brüning: The resolution is required, for example, in engraving applications where many, many subsequent layers are engraved, i.e. we sweep across the roller, draw back, and engrave it again. You need to hit exactly the same spot otherwise the second layer will not match the first. This is where you need such precision. That was not required in the former single-step engraving technologies. Beside the printing applications (electronic-, security-, Intaglioprinting), micro embossing applications in the area functional surfaces and security applications will come up, e.g., we realised micro calottes with a radius of 6 µm for the flat screen manufacturing.

LTJ: ***Will there be a follow-up or are you satisfied with the results for the time being?***

Brüning: There already is a follow-up project focusing on beam sources but without participation of the users. Probably, because they would build up too much time pressure. There might be a development in this direction within the next year or two. In terms of scanning technology, the whole concept is not yet fully exploited. Until now, we only showed that a fast scanner is required for fully deploying fast lasers. Fast scanners, in particular, might have been slightly out of focus in the past years, but particularly here in Germany we need the high productivity; it really is a vital necessity. High scanning rates are a substantial sales argument for our products.

Excimer Lasers for Active-Matrix-LCD and Active-Matrix-OLED Based Flat Panel Displays

Interview with Dipl.-Ing. Rainer Pätzel (Coherent GmbH, Göttingen, Germany)

The 2nd place has been awarded to Rainer Pätzel and his team for the development of a new 308 nm excimer laser that enables faster, brighter and thinner AM-LCD and AM-OLED flat panel devices and thus, e. g., the fabrication of large OLED-TV displays of up to 55 inches in diameter. By transforming their production lines from generation 4 to 6 size, manufacturers are able to increase throughput and decrease unit costs by up to a factor of four.

LTJ: ***Mr. Pätzel, for some years, industry has been deploying excimer lasers for manufacturing flat screens (see also "UV lasers in flat screen manufacturing", LTJ 1 (1), 2004, 51-55). What advances have we seen since then?***

Pätzel: Indeed, we have been working on developing this low temperature poly-silicon process (LTPS) for more than 12 years. However, we are not direct users of the technol-

ogy but rather manufacture the equipment needed, lasers and the optics in particular. It took us so long because it involved industrial innovations in the true sense of the word, i.e. determining how to switch production processes to a different kind of technology.
And also we had to consider sales markets of the end products in the field of displays. Initially, enabling flat screens provided the basis for delivering information on mobile equipment. Trends are heading heavily towards HD and long battery life (several days, if possible). All this requires considerable changes in manufacturing technologies. Thus, LTPS, being relevant for us laser manufacturers for years, is becoming more and more interesting for display manufacturers at a larger scale. Products like iPhone and Galaxy are known, and the trend will continue towards visions such as OLED television screens. Backplanes produced here, i.e. the TFT array which triggers the pixels to transmit image information, are particularly powerful. TFT are small, have high electron mobility, switch fast and efficiently, and are thus ideal for brilliant, low-energy displays with high resolution, i.e. ppi (pixels per inch) of more than 250. Since 2004, an industrial sales market has evolved which can only be tapped with appropriate manufacturing technologies for large display glass panels and with short cycles, i.e. with high output. Such a technology could run on a 24-hour basis.

LTJ: ***What technological developments made the new results possible?***
Pätzel: What we do, as we call it, is to scan the glass but we actually move the glass across a stationary laser. The laser beam here is a line of 750 mm, which is the longest

Rainer Pätzel explains his team's innovation. (Image: C. Teutsch, Wiley-VCH)

available today. Because of its length and the limited energy of the laser, it is kept narrow in order to maintain the required pulse energy density. When this line hits the glass, it melts an approximately 50 nanometer thick layer of amorphous silicon which recrystallizes during solidification. Line length is crucial because it has an impact on cycle times. For large glass panels, where conventional processes call for only two scans, this is the point to decide. Today, this allows Generation 6 (1.80 m × 1.50 m), Generation 5.5 (1.30 m × 1.50 m), the 1.50 m fitting precisely to 0.75 m. Realizing two scans fosters the acceptance of the technology.

LTJ: ***Are there these size requirements in OLED technology as well?***
Pätzel: For OLEDs, we have the same prerequisites in terms of size as in display technology where for years we said "the larger the better". This trend has more or less come to an end for amorphous silicon with televisions. Generation 10 is the largest, about 3 m × 3.50 m, and has been on the market from Sharp for three years. It's hard to make money in this sector. For LTPS, it is still a matter of display economy since large glass means many displays, means a lot of money and low cycle times.

LTJ: ***How big a leap was it from the former systems to what you have developed by now?***
Pätzel: In laser power, we see an increase by a factor of 2.5. But when you combine this with line length and the deployment of large substrates, customers benefit from a fourfold rise in throughput. The synergies are quite obvious in this example.

LTJ: ***What kind of development was necessary in order to obtain the new power level at this line length with respect to beam shaping, constant fluence, etc.?***
Pätzel: What makes the laser special is its stability in spite of a 2½-fold increase in power. Spatial overlap and timely synchronization of two high-power UV oscillators made this possible. Another point crucial for the optics is that we mix two beams that are completely mutually incoherent. Thus, we reduce the overall coherence in the optical system and also effects usually inevitable in such homogenizing systems. As Prof. Poprawe put it so well, there are many new things and also great ideas but innovations yield a real change in production technologies and create a system which is stable and industrially utilizable.

3D-Capable Co-axial Laser Brazing Head with Integrated Seam Tracking

Interview with Dr. Markus Kogel-Hollacher (Precitec Optronik GmbH, Rodgau, Germany)

Markus Kogel-Hollacher and his team were nominated for their coaxial wire feed unit within a multi-kW fiber coupled diode laser. The new laser brazing head enables direction independent processing, high stability of the process, less demanding programming of the robot path and processing of small seam radii.

LTJ: ***What problems are users of today's processing heads for laser brazing facing and what direction did your innovation aim at?***
Kogel-Hollacher: The state-of-the-art technologies have the disadvantage that they depend highly on the processing direction. You have the wire, fed to the process ahead of the laser, and directing the process. In addition, a precise orientation to the seam has to be guaranteed otherwise the process won't work. A coaxial wire feed overcomes this problem. It allows far better angle-independent processing laterally as well as in travelling direction. In fact, you can turn around corners, the motion of the processing head is completely unrestricted. Also, with this head and this optical concept the user has at hand a technique much more tolerant to certain seam geometries. It makes the process a lot simpler and more robust and you can realize much more complicated concepts. In addition we are now able to run much higher processing speeds. This is due to the fact that our beam-guiding concept makes the

Markus Kogel-Hollacher outlines the advantages of the new laser brazing head. (Image: O. Dreissigacker, Wiley-VCH)

laser radiation hit the filler-metal wire before it touches the workpiece and thus preheats the wire. Currently, velocities of 3.5 m/min are standard. Doubling the velocity would enable the manufacturer to process an entire car body with a single head, i.e. one laser and one robot. These cost issues naturally also argue for deploying our processing concept. End users involved in the projects reported that today they spend two entire days to teach the brazing seam of a new body. Initially, the processing head is taught roughly at the seam, and subsequently, software is used to optimize the robot path. This is repeated several times. Due to the great flexibility with respect to angular orientation between head and process, teaching a new seam would only require hours. This allows users to evaluate new concepts much more swiftly which is interesting not only in series production but also in experimental setups.

LTJ: ***And so all you need to do is to exchange the robot's head and the rest can run as ever?***

Kogel-Hollacher: Exactly. Our concept is designed for diode lasers, the type of laser typically used for laser brazing. Our principle does not require a particularly sophisticated laser system. So we defined the initial conditions: a 4-kW diode laser with numerical aperture of 0.22. From this, we started out to design the entire optical concept. Of course, our competitors by now also offer coaxial systems, but they however, require higher beam quality. In contrast, our technique works with cheaper lasers.

LTJ: ***Besides the increase in speed, is there an effect on quality?***

Kogel-Hollacher: Due to the fact that the wire is preheated, it adapts and adheres much better to the joint. The transition between sheet metal and seam and back to the metal is as homogeneous as the customer wants it for directly subsequent coating processes. Our end users were very impressed by the results demonstrated in cross-sections.

LTJ: ***What was the greatest difficulty in terms of technology or even collaboration?***

Kogel-Hollacher: Concerning collaboration, we didn't face any difficulties at all. The only difficulty we initially had was in adjusting the optics. At the time, we did not have any precision adjustment equipment for the optics so you had to adjust and then quickly assemble everything so that it would remain in position. Of course we improved this detail during the following development steps. But de facto the solution is straightforward and actually very simple. Naturally, a great advantage for us is that we are able to use a majority of our existing components. Precitec builds processing heads in a large variety of fields. We have collimators, beam deflectors, beam splitters for adding camera equipment and so on. Such components come practically off the shelf.

LTJ: ***Are there any ideas for further developments? Can all this be deployed in other branches?***

Kogel-Hollacher: There is the idea to investigate whether the optical concept can be used in other laser processing segments where additional material is used, but the first task is to bring this laser processing head into production and gain experience from the shop floor. Nevertheless for us, the main point is the ringshaped projection which allows tracking. The tracking software contains a considerable amount of innovation which can surely beused in other applications as well.

The interviews were conducted by Oliver Dreissigacker and Carmen Teutsch.