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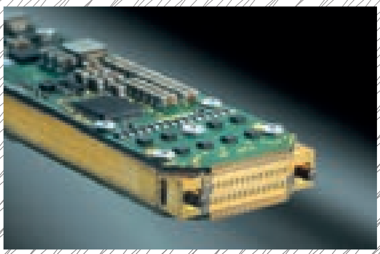
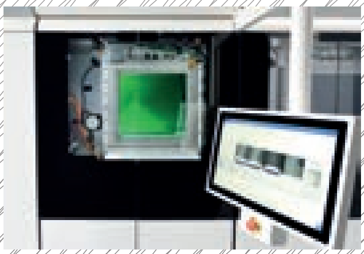
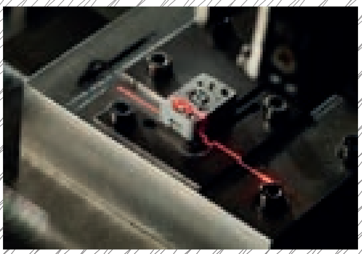
■ **DSPE CONFERENCE 2016** REPORT ■ DIE-BONDER **SYSTEM ARCHITECTURE**
■ THEME: **ADDITIVE MANUFACTURING** ■ **PRECISION FAIR 2016** PREVIEW







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Professional journal on precision engineering and the official organ of DSPE, the Dutch Society for Precision Engineering. Mikroniek provides current information about scientific, technical and business developments in the fields of precision engineering, mechatronics and optics.
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The main cover photo (featuring an impression of the DSPE Conference 2016) is courtesy of Iris Wuijster. See the DSPE Conference 2016 report on page 45 ff.

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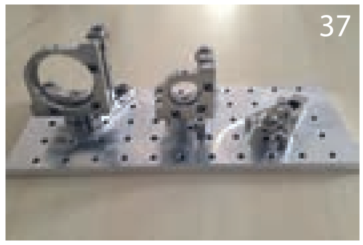

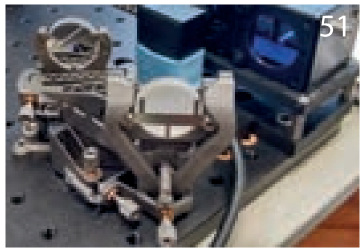

FEATURES

EDITORIAL

3D METAL PRINTING HAS **GROWN UP,** BUT DUTCH MANUFACTURING IS STILL PLAYING **CATCH-UP**

During the past two years, additive manufacturing (AM) technologies – more commonly known as 3D printing – have matured rapidly. Initially, poor part and process performance limited potential applications to rapid prototyping. Now, series production of structurally loaded parts in demanding applications is within reach. But what has changed during the past two years and what will be the impact of this change?

Recent innovations in computer aided design (CAD) and engineering (CAE) software have improved their usability and capability. Now, engineers can optimise a design for function, leading to complex but highly efficient designs. The promise of increased operational efficiency has led to a focus of industry and research. Subsequently, there is better understanding of AM's design freedom and its process windows. Now, these complex designs can be produced accurately and cost-effectively by select organisations. The result? Less resources used in the operational phase. A major challenge remaining is that software is not able to optimise a design for manufacturing. This requires the experience of a skilled design engineer, of whom there will be a great shortage in the market.

With more demanding applications, new requirements on part and process performance emerge. For specific applications, such as medical, dental and aerospace, certification and regulation are now in place. As a result, AM is (becoming) the main production method in various applications, e.g. dental bridges, medical implants, aerospace brackets and specific tooling. Novel testing methods are being developed, which align with the high-mix, low-volume nature of AM. These methods – such as process simulation or in-situ process monitoring – enable flexible validation before or during production. As opposed to post-production testing based on statistics, which limits the benefits of AM. In addition, increased speed and ease-of-use are required. A new generation of metal AM machines is coming to market, geared towards industrial series production of functional end products. The MetalFAB1 by Additive Industries is a good example.

A fully digital value chain – supported by AM – enables radically new business models. However, understanding the benefits of AM is challenging. It requires you to look beyond what is right in front of you and often results in increased process complexity. For example, a medical implant produced with AM may be five times more expensive. But due to digital planning and a better form fit, the operation time is reduced and the patient return rate reduced. These benefits affect multiple elements in the value chain and require collaboration and communication to capture. For most organisations this is challenging; it requires people to take ownership of a problem and take control of internal and external processes. For true business model innovation, the interaction with the customer must also change, involving the customer early on and continuously.

Few organisations know how to do this and the Netherlands is no exception. Successful implementation of metal AM requires two to three years of dedicated focus for a single organisation. While the number of metal AM machines in the Netherlands has increased in the past two years, adoption is far from reaching critical mass. Compared to the global and European situation, the sense of urgency is missing here. Will the Dutch manufacturing industry be able to catch up? If so, it must act now and act fast.

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LONG STROKE / SHORT STROKE

As equipment and solution provider for NXP's back-end semiconductor factories, the Industrial Technology & Engineering Center (ITEC) has introduced the successor of its high-speed die-bonding and die-sorting platform, the ADAT3-XF. It includes 300mm wafer handling capability, increased throughput & accuracy as well as improved serviceability and shorter conversion times. The development team faced a few interesting challenges, such as a complete redesign of the frame and the introduction of a short stroke / long stroke wafer table with balance-mass functionality.

THIJS KNIKNIE, KEES HAZENDONK AND JOEP STOKKERMANS

The ADAT (Automatic Die ATach) platform is a pick & place machine dedicated to back-end semiconductor processes.

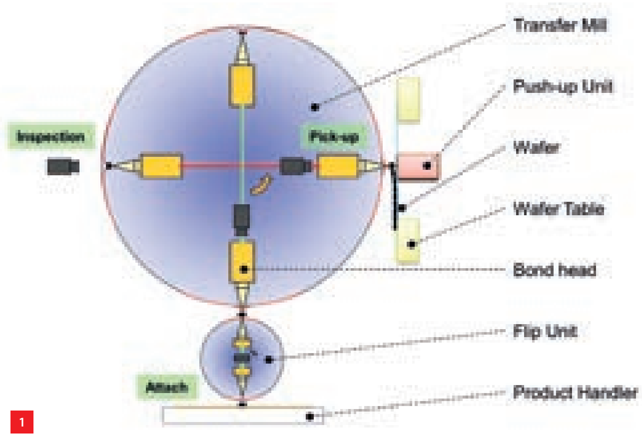
Two main processes are key in the ADAT:

- Die bonding: in this process a semiconductor device (die) is picked up from a sticky foil with separated dies, usually from a sawn wafer. The die is bonded (attached) on a variety of substrates (lead frames) by solder flux/paste, glue or an eutectic bonding process.
- Die sorting or taping: a product (bare silicon or a package) is picked up from the foil and placed in tape, which is sealed after placing the product.

ADAT3 architecture

The ADAT3 concept is centred around its Transfer Mill, a rotating axis with four so-called bond heads (Figure 1). The concept of having four rotating bond heads enables parallelised pick & place processes, roughly doubling the production speed compared to a sequential pick & place process. The wafer is positioned vertically in the machine by the Wafer Table. For a fast and repeatable pick-up process, a Push-up Unit is located behind the wafer to push up a die from the wafer foil. Below the Transfer Mill a variety of Product Handlers is positioned for die placement on several substrates (lead frames) or tape.

The breakthrough (patented) transfer mill concept was introduced with the ADAT3 in 2003 and boosted the machine speed with a factor of two with respect to the earlier ADAT2 with transfer arm. For flip-chip production, a flip unit is optionally positioned under the transfer mill.



1 ADAT3 architecture. Three steps can be distinguished: Pick-up, Inspection and Attach, indicated with green boxes. Contributing modules are depicted with dashed lines.

Why a new ADAT3-XF platform?

The ADAT3 die-bonding and die-sorting platform has proven its competitive advantage for the last 15 years in terms of output speed and product placement accuracy and by enabling new package innovations and processes. At this moment the current ADAT3 architecture is at its limits in terms of accuracy and speed. The next step in the ADAT3 roadmap includes further speed and placement accuracy improvements, 300mm wafer handling capability, but also extending product quality inspections and platform flexibility. The additional "XF" in ADAT3-XF therefore stands for extended speed (Fast), Flexibility and Functionality.

High-level requirements

Basically, the challenge is to have a capability for higher speed and a smaller die placement accuracy within the same concept. This implies that the shorter cycle times that are required for speed-up should not result in unacceptable dynamic disturbances to the positioning modules.

AUTHORS' NOTE

The authors all work at NXP ITEC in Nijmegen, the Netherlands. They wish to acknowledge their development partners MI-Partners, Sioux CCM, VDL ETG and Cortexon for their collaboration and support to meet time-to-market. This article was, in part, based on a presentation at the DSPE Conference 2016 (see the report on page 45 ff.).

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The XF platform will also have capability for new applications. Maintaining the vision of the ADAT platform to be a one-stop-shop for high-speed die-bonding and die-sorting applications, the new applications and processes are added to the existing platform.

Additionally, the assembly factories and supply chain demand a more flexible platform in terms of conversion time and cost of ownership. Modularity, accessibility and shorter conversion times thus get full attention as well.

NXP and ITEC

NXP Semiconductors enables secure connections and infrastructure for a smarter world, advancing solutions that make lives easier, better and safer. As the world leader in secure connectivity solutions for embedded applications, NXP is driving innovation in the secure connected vehicle, end-to-end security & privacy and smart connected solutions markets

The NXP Standard Products business is an industry leading supplier of Discrete, Logic and PowerMOS semiconductors focussed on the Automotive, Industrial, Computing, Consumer, and Wearable application markets. NXP Semiconductors announced an agreement to divest its Standard Products business to a Chinese consortium. At the close of the transaction, the NXP Standard Products business will be branded Nexperia, which will be headquartered in Nijmegen, the Netherlands.

The NXP Industrial Technology & Engineering Center (ITEC) is an internal industrial solution provider of semiconductor back-end equipment and manufacturing IT. ITEC is an integral part of the business unit Standard Products. Competing in high-volume, low-cost markets requires a focus for lowest cost of ownership in the manufacturing set-up and infrastructure. A large part, from waferfab to final test, is controlled by internal manufacturing. The development of exclusive, high-end solutions brings a competitive edge to NXP's standard products manufacturing. Vertical integration enables businesses by tailored solutions and exploiting the synergy with package innovation and test innovation.

Project management

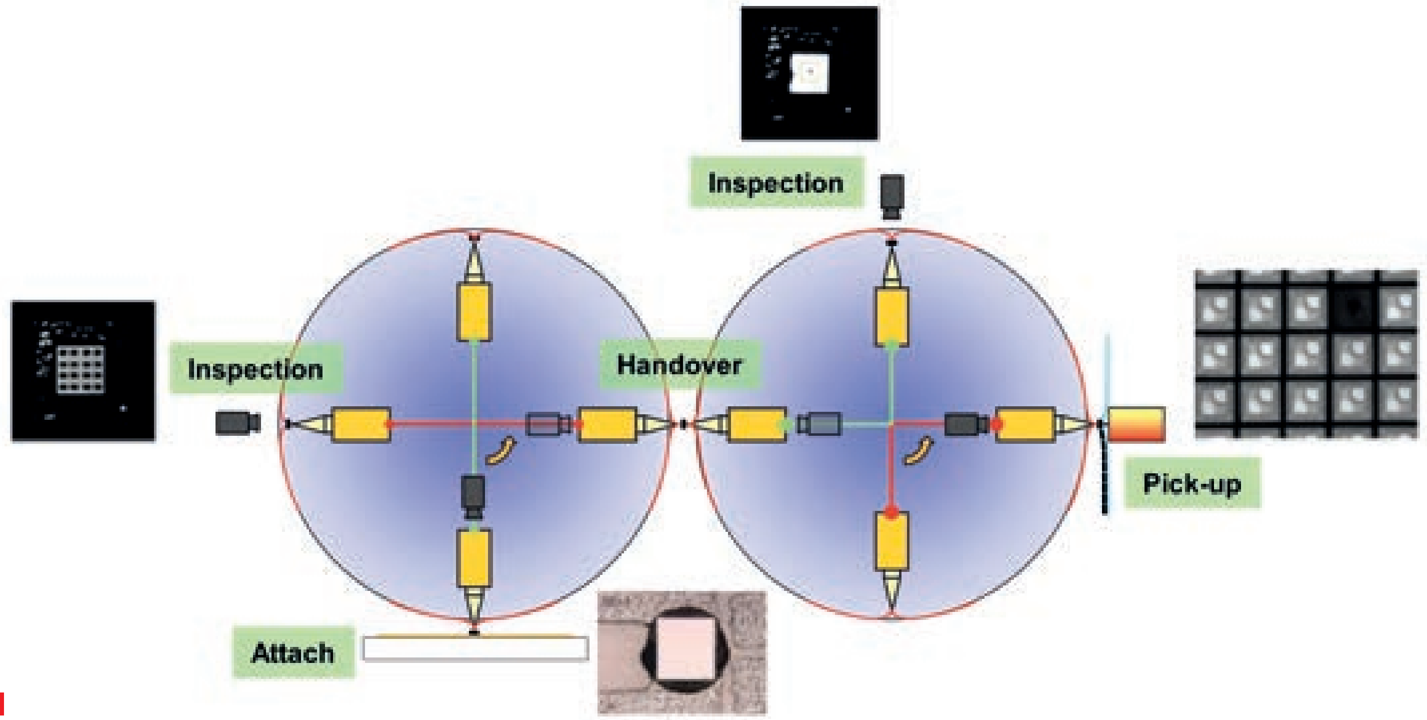
Development of new (mechatronic) modules such as the frame, transfer mill, wafer table and push-up unit started in the pre-development team as high-level-definition building blocks for the new platform. For every building block a small team continued with conceptual modelling calculations and the definition of alternative solutions. In the architecture team, with all disciplines represented, the alternatives were ranked and the best solution was worked out further. In the development phases the design teams adopted standardised techniques within NXP to judge the design: FMEA for risks and failure, DfX for performance excellence and quality, and DfMA for manufacturability and costs. As buying of these complex mechatronic modules was soon abandoned as an option, co-developments with among others MI-Partners and CCM were started, led by the architects of NXP ITEC.

The choice of working with co-developers (MI-Partners was actually already involved in an earlier stage for concept studies and defining architecture) made it possible to use the experience and extra resources of the co-developers to build prototypes and redesign them if necessary and allowed in the short time frame. In parallel with the prototype projects, module improvement projects, software and motion control developments started at ITEC. In the end the usage of co-developers, controlled by the architecture team, and parallelised software development resulted in a very short time-to-market and first-time-right result.

ADAT3-XF architecture

Double Transfer Mill

To add more flexibility in machine configurations and to benefit even more from the power of the transfer mill concept, the XF platform introduces the 'double-mill' concept. This enables fast conversion from flip to non-flip processes and secures the roadmap for speed-ups.
Figure 2 shows the concept schematically. Products are picked up by the Pick-up Mill from a sawn wafer on foil at the right hand side. After quality and alignment inspection on the top, the product is handed over to the Attach Mill. A second quality and alignment inspection is done on the other side of the product and the product is placed on the lead frame. After placement the third inspection is done.



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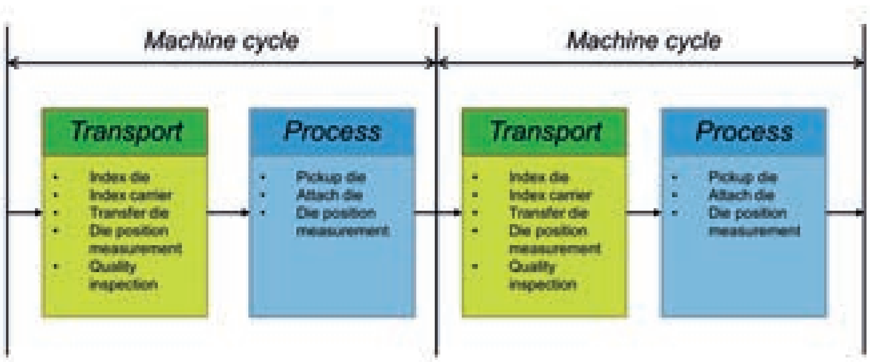

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2 *ADAT3-XF transfer principle. See text for explanation.*

3 *General functional behaviour of the ADAT platform.*

The double-mill concept introduces more calibrations and adjustments; with two transfer mills it is required to mechanically align four bond heads with respect to each other on one transfer mill and with respect to the other transfer mill. The alignment problem is solved by using dedicated alignment cameras and an innovative way of calibrating and compensating.

Machine cycle

The ADAT3 platform combines micrometer pick & place accuracy with extremely short cycle times. This is realised by innovative mechatronic design; however, even more important is the machine cycle design. A simplified overview of the ADAT machine cycle is shown in Figure 3.

The processes can be roughly divided into:

- A transport or die-select phase: all indexing modules are moving to the next position and inspections are done on processed and unprocessed products.
- A process or die-transfer phase: pick-up, handover and attach processes take place together with additional inspections.

It must be said that this is a very rough division, because in practice the machine cycle of the ADAT is highly integrated and optimised for machine speed. Transport and process functions overlap and interact. This requires perfect synchronisation and minimal communication delays, which is realised by the software architecture and a dedicated motion control platform: FlexDMC.

Dynamics & control

The pick & place processes in the ADAT require an index step for almost all modules. This implies that the modules have a requirement on settling behaviour, rather than tracking behaviour. This gives two advantages:

1. Offsets and low-frequency drift phenomena can be compensated by adapting the setpoints based on information from the inspection optics. This can be seen as a low-frequency feedback loop with the inspection result as input and the position setpoint as output.
2. Dynamic disturbances are acceptable provided they settle quickly enough after finishing the setpoints.

In the ADAT3 all modules involved in die transfer are mounted on a single frame. An advantage of this architecture is that the modules have fixed reference

PRINTING BY THE RULES

The additive manufacturing (AM) of high-quality products requires knowledge of the 3D-printing process and the related design guidelines. Allthough AM has been around for some years, many engineers still lack this knowledge. Therefore, Fontys University of Applied Sciences sets great store by training of engineers, education of engineering students and knowledge sharing on this topic. As an appetiser, this article offers a beginner's course.

SJEF VAN GASTEL

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AM has most definitely been a hype in recent years and is now producing relevant applications; see Figure 1 and other articles in this issue. Nevertheless, many engineers have not familiarised themselves with AM's 'unique selling points':

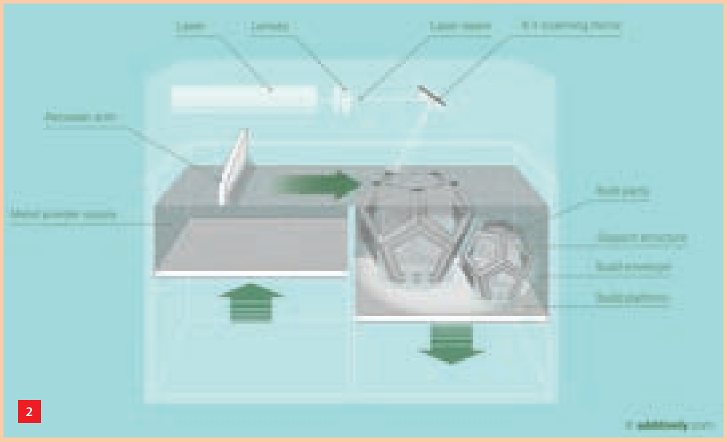
- customisation of parts and products (for example, for medical applications and spare parts);
- freedom of design (complex features that cannot be conventionally machined);
- mass reduction and stiffness optimisation (using topology optimisation: putting material only where it will add value);
- integration of functions (potentially leading to new design principles);
- specific material properties (of optical surfaces, for example).

One of the barriers for adopting AM may be the lack of knowledge of the appropriate design guidelines. At the ObjeXlab of Fontys University of Applied Sciences, these AM design rules are the subject of research and knowledge sharing, through research projects, education and training. The focus is on the design guidelines for two popular AM technologies, i.e. SLM (selective laser melting) and FDM (fused deposition modelling), for metals and plastics, respectively; see the box on the next page.

1 *Conventional design of a steel-cast bracket (left) and the corresponding topology-optimised design of the titanium AM-made bracket (right), printed on an EOS machine. Source: Airbus Group Innovations*

SLM and FDM

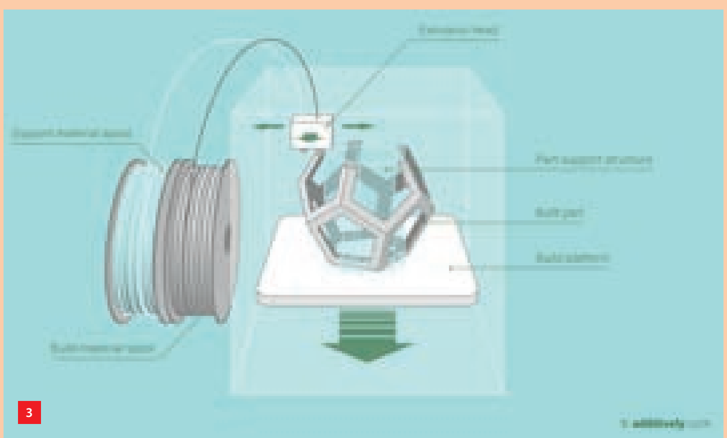
With SLM (Figure 2) a metal powder is distributed equally in a thin layer over a build platform (powder bed), by means of a roller or a squeegee. Typical layer thickness is around 25-100 µm. An (X,Y)-controlled laser beam melts together the powder particles in the build layer (and with the layer below). After building a slice of the component, the platform will sink by one layer thickness and a new layer of powder will be applied over the previous one.



2 *Selective laser melting (SLM) printing principle.*

The powder bed can be heated to reduce excessive temperature differences between the particles that should be joined together and the superfluous particles. Also, the atmosphere inside the machine should be low in oxygen content to reduce unwanted oxidation. This can be achieved by applying a nitrogen or argon atmosphere or by means of evacuation (electron beam melting). After the component has been built, the unused powder should be removed (after cooling down to room temperature), the part has to be separated from the build plate and mechanical stress has to be relieved. Density will be 99-100%; sintering is not necessary.

With FDM (Figure 3) a plastic wire (filament) is fed into a heated extruder where the solid plastic is weakened and pressed through a nozzle. This nozzle is moved in the horizontal plane by means of a software-controlled gantry. The movement path of the nozzle corresponds to the slice outline of the layer to be built. Below this nozzle is a build platform which is lowered each time a layer of the object has been built.

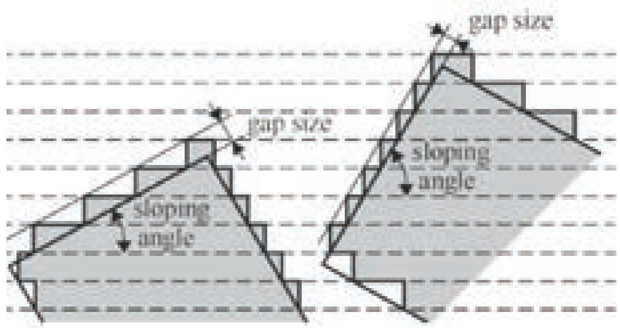


3 *Fused deposition modelling (FDM) printing principle.*

SLM design rules

Some important SLM process parameters are layer thickness (vertical pitch), laser power, scan velocity and distance between print tracks (hatch distance). The printing resolution is determined by the interplay between these parameters and the powder composition (type and size distribution). For a high-resolution print, low laser power, low scan velocity and low layer thickness are required, whereas a high building speed requires high laser power, high scan velocity and a thick powder layer.

Naturally, the resolution of the printing process influences the surface roughness, depending on the sloping angle of the surface under hand; this is called the staircase effect (Figure 4). The steeper the surface that is being printed, the smoother the result, depending on the layer thickness. The exact nature of the melting process also has its influence on the surface quality. For high-quality surfaces, remelting or other post-processing options are required.



4 *The staircase effect.*

A product-specific design parameter that has to be considered is the printing orientation of the product. Mechanical properties of SLM-printed products are, to a large extent, independent of the printing direction, but they do depend on the scan strategy. The orientation of the product with respect to the build plate (and hence the total processing set-up) can be selected in a trade-off between productivity (the number of parts stacked on the build plate for one printing run) versus the interaction of the squeegee with the product (the risk of damaging thin or thin-walled parts of the object). The squeegee movement has to be as much as possible in the 'stiff direction' of each part of the product. Stress relief considerations also play a role in determining the optimum printing orientation.
An alternative is to increase the stiffness by adding support structures, for example 'bridges' that connect vulnerable parts (Figure 5).

MEETING POINT FOR **PRECISION TECHNOLOGY** AND DSPE MEMBERS

On 16 and 17 November 2016, the sixteenth edition of the Precision Fair will once again be the international meeting point for precision technology. This free event at the NH Conference Centre Koningshof in Veldhoven, the Netherlands, features some 300 exhibitors (specialised companies and knowledge institutions), among which nearly sixty DSPE members.

The Precision Fair has a two-day lecture programme which lists fifty presentations. The special Big Science keynote track was very successful last year and is therefore again on the menu. It features projects like CERN (nuclear research), ITER (nuclear fusion energy) and E-ELT (astronomy). (Dutch) high-tech suppliers can learn about their recent technological developments and new tenders. The International Meet & Match Event will be hosted on both fair days as well.

Exhibition

The heart of the fair, however, is the exhibition, which covers a wide array of fields, including optics, photonics, calibration, linear technology, measuring equipment, micro-assembly, motion control, piezo technology, precision tools, sensor technology, software and vision systems. A sneak preview of a few innovations on display is presented on the following pages.

Awards

Just before closing each fair day, event partner DSPE will organise an award ceremony. On Wednesday 16 November, the Ir. A Davidson Award will be presented to a young precision engineer who has worked for some years in a company or institute and who has a demonstrable performance record. On Thursday 17 November, the Wim van der Hoek Award will be presented to the person with the best mechanical engineering design graduation project at one of the three Dutch universities of technology.

Media partner Mikroniek will report on the highlights of the Precision Fair 2016 in its December issue.

DSPE members exhibiting at the Precision Fair 2016

Stand number		Stand number	
288	4TU.High Tech Systems	277	Janssen Precision Engineering
150	Alten	292	Leidse Instrumentmakers School
293	Avans Hogeschool	282	MathWorks
166	BKB Precision	5	Maxon Motor
199	Bosch Rexroth	267	Mecal
162	Bronkhorst Nederland	128	Mevi Fijnmechanische Industrie
125	Ceratec Technical Ceramics	200	MI-Partners
96	Connect 2 Cleanrooms	7	Mitutoyo Benelux
130	Demcon Advanced Mechatronics	269	Molenaar Optics
235	Dürr Ecoclean	203	MTA
275	Dutch Society for Precision Engineering	134	Newport Spectra Physics
132	ECN (Energieonderzoek Centrum Nederland)	25	NTS-Group
281	Ertec	260	Oude Reimer
138	Etchform	181	Phaer
139	Festo	194	Philips Innovation Services
129	Focal Vision & Optics	137	PI Benelux
293	Fontys Hogeschool voor Engineering/Mechatronica	16	Roelofs Meetinstrumenten
103	Frencken Group	293	Saxion Hogeschool
6	Germefa	157	Settels Savenije group of companies
34	Groneman	104	Sioux CCM
293	Haagse Hogeschool	119	Sumipro
31	Heidenhain Nederland	86	Technobis Group
105	Hembrug Machine Tools	51	Teesing
38	Hittech Multin	140	Tegema
101	Ter Hoek Vonkerosie Rijssen	37	TNO
293	Hogeschool Utrecht	112	VDL ETG
48	Holland Innovative	228	Veco
276	The House of Technology	144	VSL
135	IBS Precision Engineering		
120	Irmato		

Impression of the Precision Fair 2015. (Photo: Jan Pasman/Mikrocentrum)

Precision Fair

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