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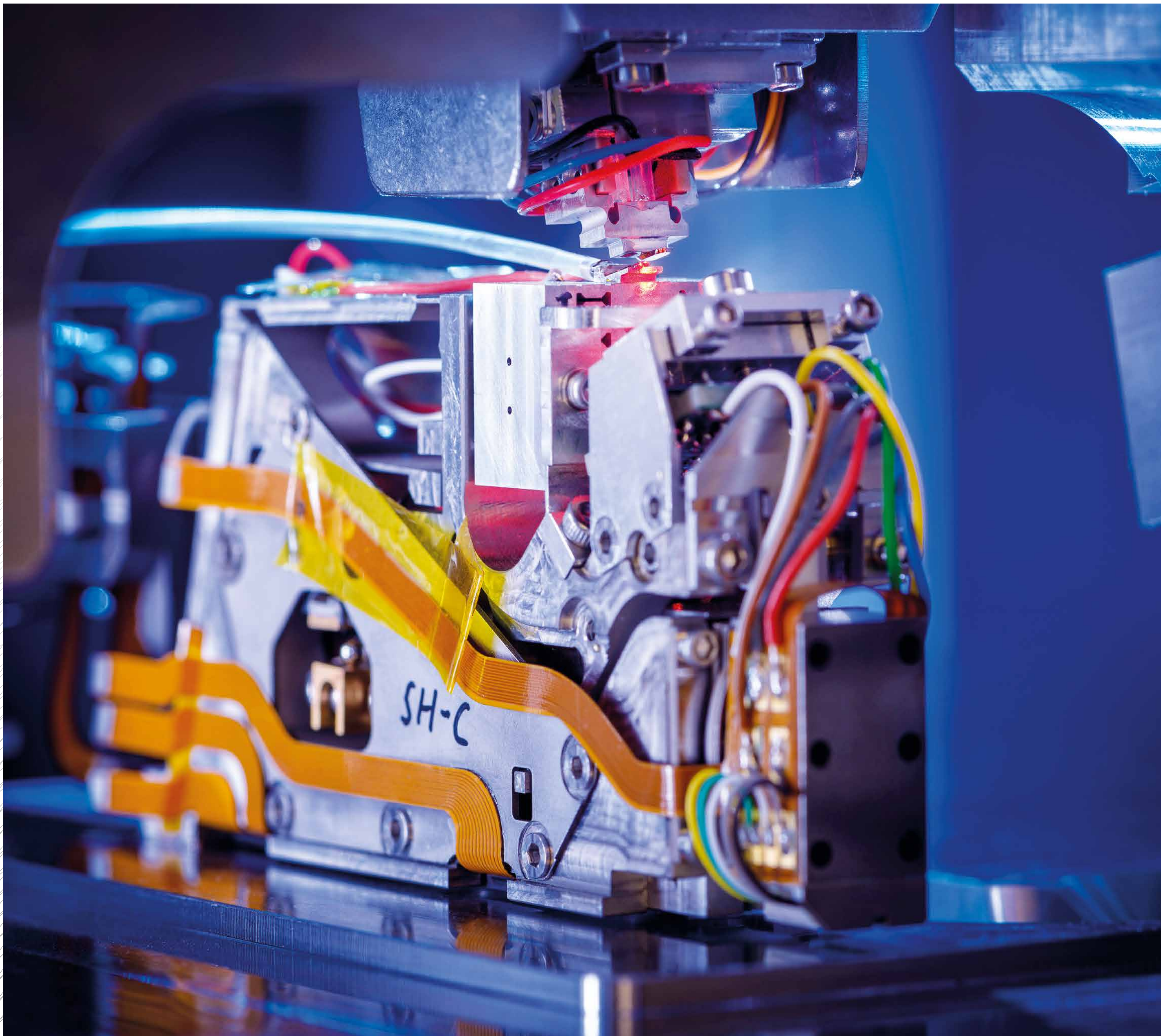
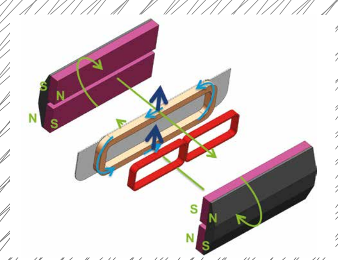
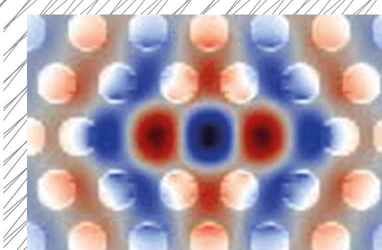


- THEME: **PRECISION MECHATRONICS**
- **DSPE CONFERENCE 2018** CATALOGUE
- **EUSPEN CONFERENCE** REPORT
- **SYSTEMS ENGINEERING** FOR HIGH-END R&D





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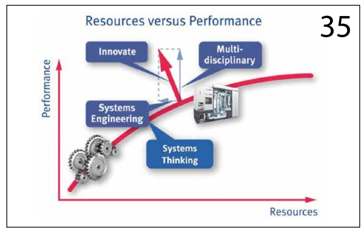

FEATURES

PUBLICATION INFORMATION

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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.
The journal is read by researchers and professionals in charge of the development and realisation of advanced precision machinery.

DSPE
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The main cover photo (featuring a miniaturised AFM scan head below a cantilever exchange unit) is courtesy of Rogier Bos/TNO. See the abstract for the DSPE Conference 2018 (page 16 ff) on page 27.

EDITORIAL

STATUS QUO VS BIG DREAMS

After our well-deserved summer holidays it will be high time for the 4th edition of the DSPE Conference on Precision Mechatronics. During two days with an overnight stay we share insights and strengthen our network. For our precision engineering community, accustomed to close collaboration and open communication, it may seem a 'normal' thing to continue what was once started by Philips CFT – the conference being just one fine example of this – and perhaps we are no longer even aware of the special biotope we live in and the position we have in the international scene.

When at a conference, such as euspen's annual event, international colleagues make you aware of this by expressing a mix of respect and jealousy when talking about the achievements of our small country in the field of precision engineering and the special characteristics of our community. Many times I have heard comments like:

- "Netherlands Inc."
- "Acting together and granting each other part of the success."
- "What a huge Dutch representation at the euspen Conference."
- "How come you Dutch guys take care of three of the five tutorials?"
- "You all seem to know one another."

To be honest, I think that in part this is just perception (fed by presentation), but to some extent these observations are justified. Here Philips has played an enormous role, not only emanating from all of its industrial activities, which nowadays still flourish under the Philips and other brand names, but also from the mindset of cooperation and sharing insights it has nurtured over the years. The DSPE Conference is an exponent of this mindset: sharing insights, strengthening our network and in this way contributing to a wider utilisation of the community's capabilities and competences and their better positioning in the global market.

However, pride comes before the fall. Should we be content with the status quo, i.e. doing well within Europe and hearing people say they envy our precision engineering community, or should we rather look at what is happening in China? Because once an item, e.g. self-reliance regarding core technologies, has been put on the Chinese agenda, they start working on it with great speed, and especially huge numbers of people and resources. Is that not the real standard we have to compete against? Therefore, should we next time maybe not register for a conference in an ancient European city but travel to China instead?

On the other hand, the size of a country is not the only yardstick. As Darwin already observed, survival of the fittest is not about size or strength, but about adaptability. Translated into the industrial economic setting, this means that we must cherish the enormous successes of ASML, Philips, NXP, VDL and others, and at the same time pursue our own big dreams to realise new successes.

Fortunately, we can boast of many examples of enterprising precision engineers. At Eindhoven Medical Robotics, under the leadership of Maarten Steinbuch, a new medical robot industry with hundreds of millions of sales is being dreamed up. Dutch United Instruments (a TNO-Demcon joint venture) is working on a state-of-the-art measuring machine for absolute form metrology of aspherical and freeform optical surfaces. Additive Industries, started just six years ago, has grown to be an established equipment manufacturer for industrial metal additive manufacturing systems. And Luxexcel, the only company in the world capable of 3D printing ophthalmic specialty lenses, has already reached the size of a scale-up.
These are just a few examples and I am convinced our community holds all the ingredients for a bright future: knowledge, cooperation and entrepreneurship.

Adrian Rankers
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P.S. My advice would be to be active in the DSPE community, maintain the euspen and ASPE networks and on top of that do some technology scouting in Asia.

A PARTICULAR PICK & PLACE PLATFORM

In close cooperation with NXP Semiconductors and Sioux CCM, Nexperia ITEC has developed a high-speed RFID die bonder with unrivalled quality and speed, enabling low-cost RFID label production. The high-speed and accurate web handling module and the optics modules for quality and alignment inspections are the result of an intensive collaboration, focused on choosing the right design principles at the right cost.

THIJS KNIKNIE, RAYMOND ROSMALEN, PATRICK HOUBEN AND RONALD PLAK

The RFID (radio frequency identification) market is a particularly interesting growth market for semiconductor assembly. Several sources [1] [2] indicate that the RFID market is growing with double digit percentages in the coming decade, especially in passive UHF RFID tags for retail, tickets and logistics. Market analysts [1] [2] estimate the RFID market to grow beyond 47 B$ in 2027, while in 2017 12 B$ has been reported.

RFID technology

A passive UHF RFID tag consists of a plastic or paper substrate (in industry called the 'web'), laminated with an antenna, and a semiconductor device (the 'die') that carries product information and connects to a reader. The die is glued on the web in a 'die-bonding' process, where glue is applied and the die is pressed onto the antenna. Although highly depending on the type of glue, generally a thermo-compression step follows to cure the glue and ensure a good conductive bond with the antenna. The antennas are laminated into a wide variety of products by so-called converter equipment. Examples of RFID tags and labels are shown in Figure 1.

Platform

Competing with printed barcode labels and QR codes means that the operational and material costs for passive RFID tags must be extremely low. The fully functional RFID tag or label consists of a semiconductor device, adhesive, plastic and paper, so the drive of low-cost manufacturing is evident. A combination of the smallest semiconductor in the market with low-cost antenna designs and the lowest cost of ownership for assembly of the product has resulted in the cost breakthrough that enables the RFID market growth. The challenge for die bonding is that the small contact pitch in combination with the inaccurate paper or plastic antenna material requires accurate alignment and placement.

Recently, Nexperia ITEC has released its Die Bond Web Glue (DBWG) platform for RFID production. The DBWG model is a specially developed pick & place platform that is integrated in the BW Bielomatik TagLiner RFID by BW Papersystems, a division of Barry-Wehmiller, which is a global leader in packaging, labeling and converting equipment. The highlights of the design will be presented below, as far as confidentiality allows.

1 *Typical RFID tag designs. (Source: Barry-Wehmiller)*

AUTHORS' NOTE

Thijs Kniknie (principal mechatronics engineer), Raymond Rosmalen (principal software engineer) and Patrick Houben (principal mechanical engineer) all work at Nexperia ITEC in Nijmegen, the Netherlands. Ronald Plak is a system architect mechanics at Sioux CCM in Nuenen, the Netherlands.

Part of the work described here will be presented at the DSPE Conference on Precision Mechatronics 2018 (see the programme on page 16 ff).

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The system is capable of handling the low-cost web designs with extremely high output speeds and with 100% quality control. In consecutive steps, the web is fed through the:
- Unwinding station;
- Glue station for dispensing adhesive;
- Bond station for attaching the die (or chip) to the adhesive;
- Thermocompression station for ultrafast curing of the adhesive;
- Winding station.

See Figure 2 for an overview of the process steps.

Production tolerances on the web material are too large for 'blind' placement of adhesive and die. It is required to align the web to each process position within tenths of microns, while web tolerances can go up to a few hundred micrometers. Because each process position requires its own alignment step, they all take place on a separate module. This modular approach also has the advantage that changes in the processes do not affect each other, so future technologies can be integrated in dedicated development projects.

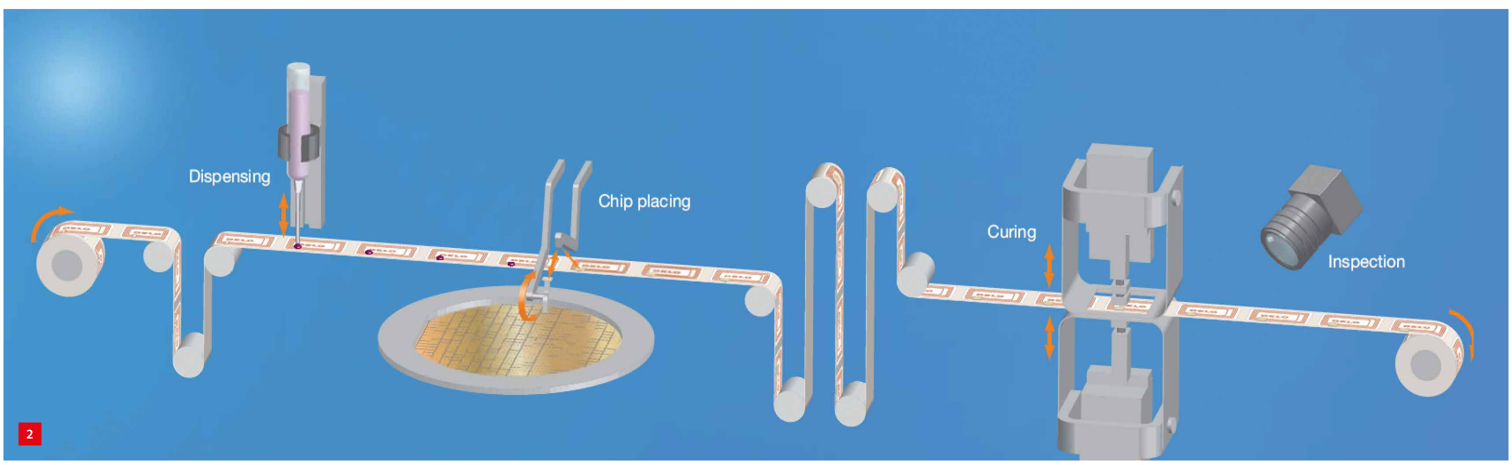
Yield and quality requirements demand 100% quality control at each process step. A functional test with a high-speed RFID reader before winding the web ensures ppm (parts-per-million) level quality for the customer. Figure 3 shows a schematic overview of the DBWG system realised by Nexperia ITEC. The dispensing, chip placing (die-attach) and curing (thermocompression) processes require (as shown in Figure 2) are performed on separate web-handling modules, each with their own camera systems.

Web handling module

Experience of Sioux CCM in web (e.g. foil and paper substrate) handling in the solar and printing industry provided a good technological base for handling flexible substrate in a continuous flow. One of the main limiting factors of positioning accuracy in web-handling systems is the relatively low stiffness of the web materials. Sioux CCM previously tackled this challenge by creating a transport system called Vexar in which the web is temporarily fixated with vacuum to a steel belt making it possible to position webs within ±5 μm over several meters. Another system developed by Sioux CCM with similar technology is the Generic Substrate Carrier [3].
With this system high accuracies can be achieved because the web temporarily gains the relatively high stiffness of the steel carrier making it robust for force variations on the web. Such a steel belt transport system however is not suitable in the RFID case, because synchronised motion is required for the die-bonding process. In addition, the web in this application is not moving in a straight line as in common web-handling systems but must be aligned in transport and lateral direction each production step to compensate for the position variations of the antennas on the web.

The solution was to design a rotating drum combined with axial motion capability. Automatic alignment of the web relative to the process positions is done with optical inspection of markers on the web. The result of each inspection is a dedicated setpoint for the X and Y position of the web. Figure 4 shows the global design of the web-handling module.
The web-handling module consists of three elements:
1. Rotational ('X') drive for positioning the web in feed direction;
2. Axial ('Y') drive for aligning the web in axial direction;
3. Web-steering unit that keeps the web on tension and on track.

The web is transported and aligned to the next product position for dispense, die-attach and thermocompression processes. During the process, movement of the web is not allowed. The output requirements demand web acceleration up to 100 m/s^2 and a velocity up to 2 m/s. The optimal drum design has sufficient structural and dynamic stiffness to enable position accuracy and minimised mass and inertia to comply with the limits of the motion control electronics.



2 Schematic overview of the RFID die-bonding process. (Source: DELO Industrial Adhesives)

LIGHTWEIGHT LIFTING

AUTHOR'S NOTE

Max van Lith graduated on the subject of this article at Eindhoven University of Technology (TU/e), the Netherlands. For this work he received a nomination for the 2017 Wim van der Hoek Award. As a Master of Science in mechanical engineering he currently works at Nobleo Technology in Eindhoven.

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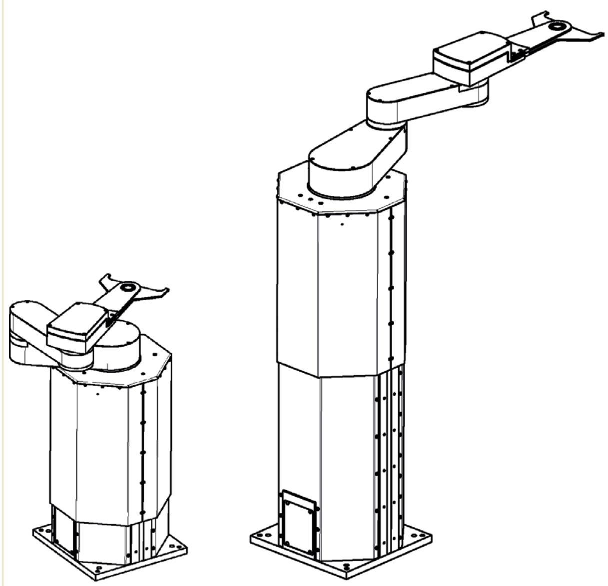
A z-mechanism that achieves high cleanliness and highly reproducible motion is proposed for use in the wrist assembly of an in-vacuum wafer handler robot. The required 10 mm stroke is made by an elastic straight guide and contactless actuation. The proposed design has no friction, is backlash-free, and requires no lubrication. A Lorentz duo-motor has been designed for actuation of z and Rx. The application of a buckled leafspring to compensate for weight and stiffness, significantly decreases static actuation forces and heat production.

MAX VAN LITH

Integrated circuits are manufactured in a layer-by-layer fashion on substrates such as silicon wafers. Multiple production steps require a clean environment and are often performed under vacuum conditions. Examples include layer deposition, etching, and photolithography. Cluster tools can provide the clean vacuum environment where these production steps can be carried out in separate process chambers. An example of a cluster tool is given in Figure 1.

In Figure 1, a wafer handler robot is placed centrally in a transfer chamber. This robot transports wafers throughout the cluster tool. A typical kinematic design of a wafer handler robot has a z-mechanism as a base. The z-mechanism serves two purposes: indexing of a 'foup' (front opening unified pod, i.e., a 'wafer box'), and picking up and putting down wafers. Note that the proposed z-mechanism only takes care of the latter function. On top of the base z-mechanism, a SCARA-type robot takes care of radial and Rz movement, as depicted in Figure 2.



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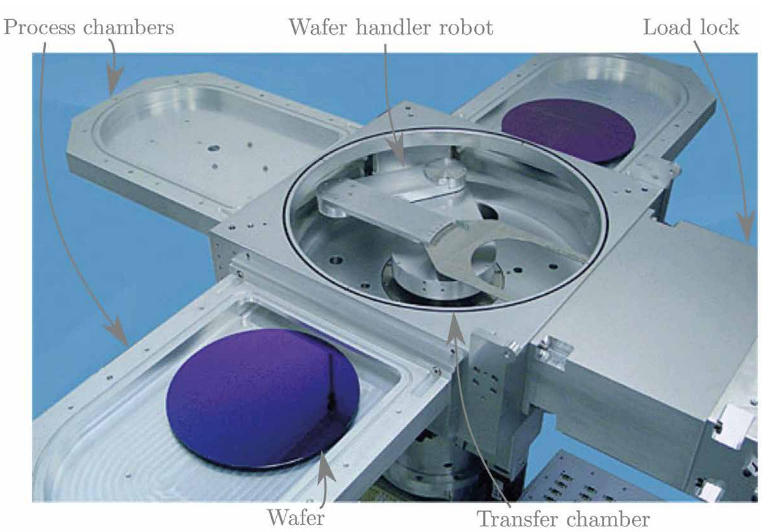

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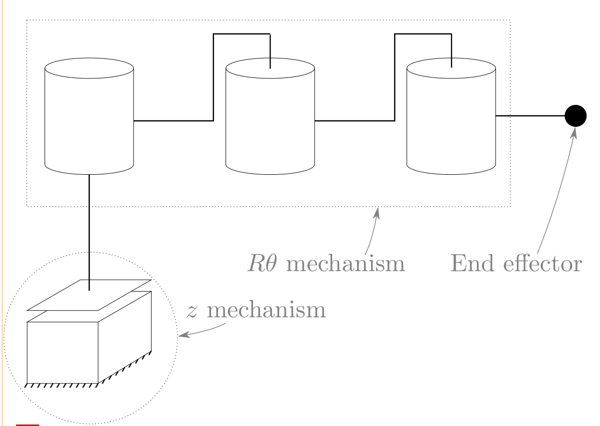
1 *Photo of a typical cluster tool with a wafer handler robot in the central transfer chamber. (Adapted from www.designworldonline.com/advanced-motion-controls-boost-wafer-handling-efficiency, accessed 19-04-2017)*

2 *Example of a typical wafer handler robot, shown in two different orientations. The base column provides vertical (z) translation. On top of the base, three serial Rz joints called the shoulder, the elbow and the wrist provide radial and Rz movement. (Source: K. Mathia, Robotics for Electronics Manufacturing, Cambridge University Press, 2010)*

The robotic arm typically has three serial Rz joints, called the shoulder, the elbow and the wrist (Figure 3a). A wafer is transported by moving the SCARA underneath the wafer and subsequently lifting the entire SCARA 10 mm. The z-mechanism therefore has to carry a weight that is significantly larger than the weight of a wafer.

The TU/e Control Systems Technology group is currently collaborating with VDL ETG to improve on the design of wafer handler robots. Key requirements are high cleanliness (both particle and molecular) and minimising the amount of moving mass.



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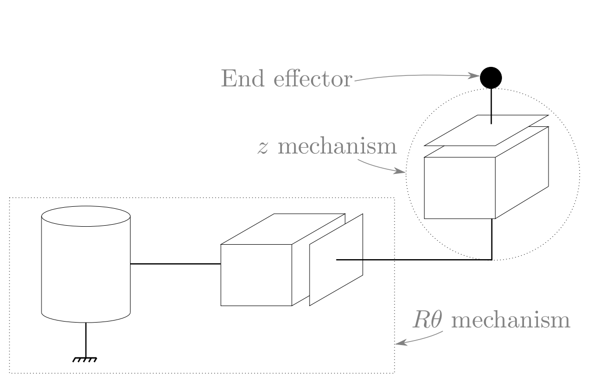


3b

3 *Schematics of the robot arm.*
(a) Conventional design with three serial Rz joints on top of a z-mechanism.
(b) New design with a z-mechanism on top of an Rz (= Rθ) joint.

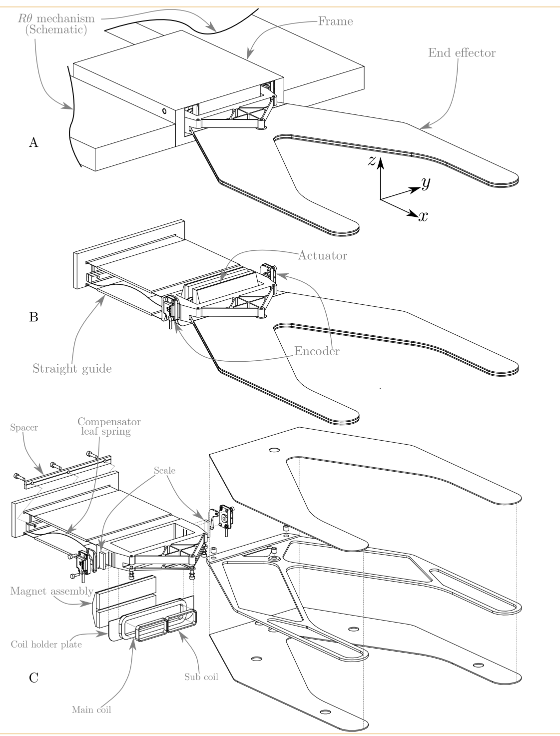
4 *Overview of the proposed design, depicting the main components.*

5 *Cross-section along the X-Z plane of the z-mechanism, depicting the mechanism within the design volume (in red).*

The purpose of this graduation project was to propose a design for a z-mechanism in the wrist assembly of the manipulator. This will decrease the z-mechanism's load from tens of kilogrammes to a few tenths of a kilogramme, allowing for better dynamic behaviour. A volume claim of 150 x 150 x 36 mm³ (x, y, z) was available for the z-mechanism.

Design overview

The proposed design (Figure 3b shows a schematic) consists of the following components. A closed box-style frame provides the interface between the wafer handler robot and the z-mechanism. The frame also acts as the 'fixed world' for the magnet assembly of the actuator and the encoders, i.e. the magnet assembly and encoder are attached to the robot side.



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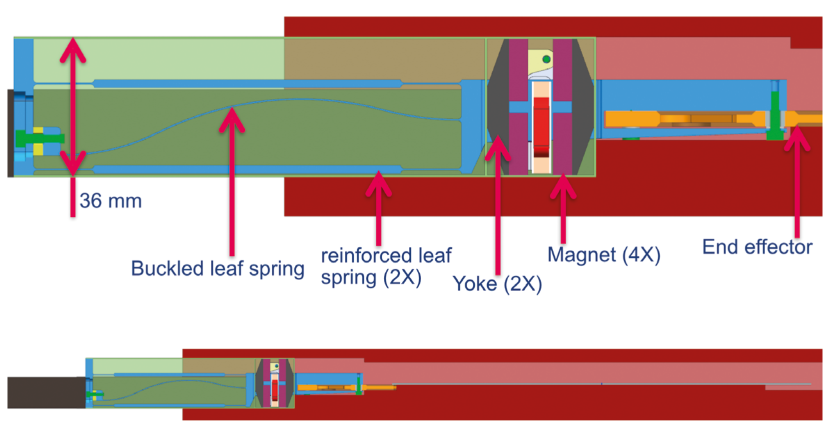
At the heart of the z-mechanism is a flexure-based parallelogram straight guide with stiffness and weight compensation. It is directly driven by a Lorentz duo-motor with moving coils and fixed magnets. Two encoders measure the z-position and the torsion along the x-axis of the straight guide. A two-pronged end-effector is attached to the front of the z-mechanism. This end-effector is made by gluing three pieces of aluminium oxide together.
The result is a stiff and lightweight sandwich construction. An overview of the proposed design is displayed in Figure 4. A centre cross-section is presented in Figure 5.

Straight guide: Passively constraining degrees of freedom

A flexure-based parallelogram is used as a straight guide for both the motion of the coils and for the motion of the end-effector. The straight guide is made from a single block of Ti-6Al-4V by wire-EDM. This titanium alloy has a favourable combination of fatigue properties, high elastic modulus and low density. The elastic straight guide exhibits no backlash and no friction. This simplifies controller design and improves motion reproducibility.



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