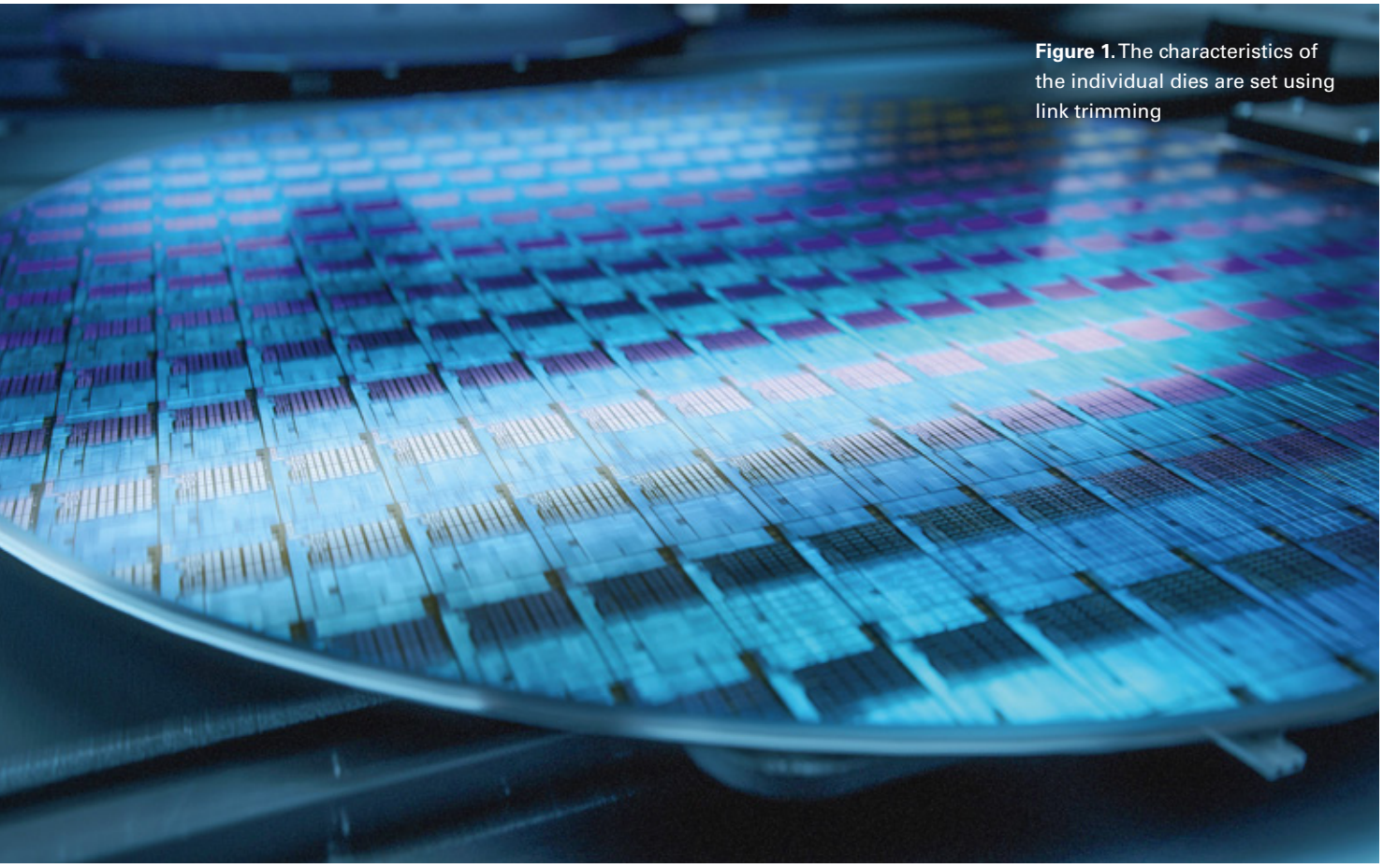

Figure 1. The characteristics of the individual dies are set using link trimming

Pictures: iStock (1), 3D-Micromac (2)

New development in air bearing technology

Increased dynamics with double **pulse decoupling**

Extremely high demands are made of accuracy and dynamics in link trimming at wafer level. On the basis of a new type of air bearing positioning system which is pulse-decoupled in the X- and Y-axis, the customer's target specifications were exceeded in several respects. The ›dynamic wafer stage‹ made its world premiere at the Laser World of Photonics.

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» The quality and precision of the laser-optic design is only half of the battle. «

Uwe Wagner.
CEO of 3D-Micromac

With memory chips, sensors or ICs for power management, the characteristics of the individual die are not adjusted until wafer probing has taken place by means of targeted cutting of microscopically fine fuses. This process, which is known as fuse cutting or link trimming, can take place using electrical voltage or targeted laser beams. The activation, programming or disabling of certain circuits

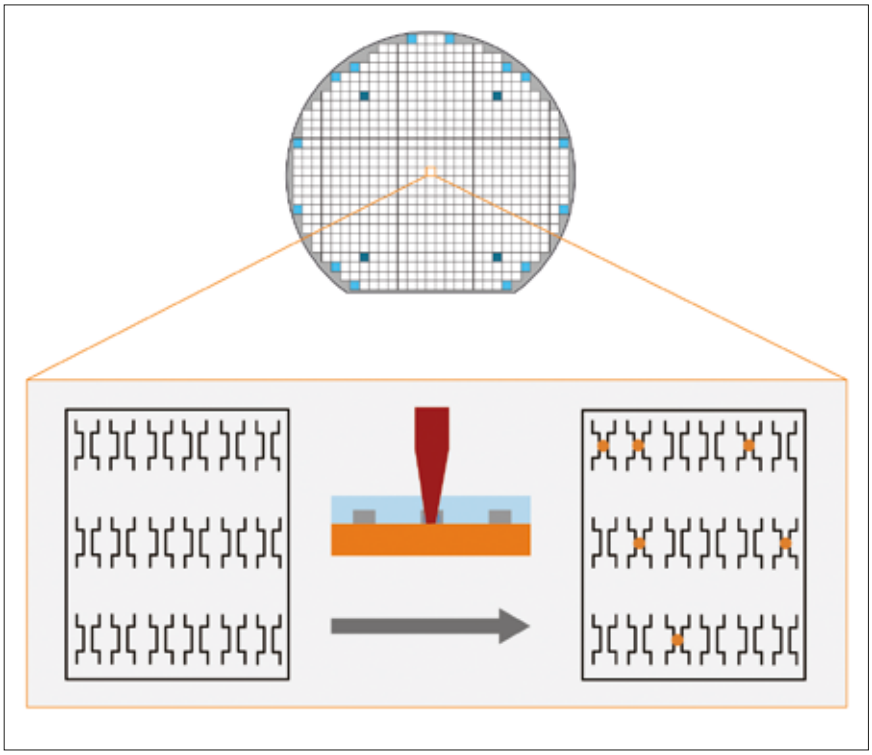

Figure 2. The micro-fine fuses are cut on the fly using a laser

is achieved in this way, in order to guarantee the functionality of the subsequent chip in the event of defects which are found during the test cycle. The trimming of sensory elements or removal of defective micro LEDs can also be realised using this technology.

Link trimming as a wafer process

In order to be prepared for future expansion of the microelectronics market and achieve higher packing densities in the system design, the resolutions and accuracies in advanced packaging must be elevated to a new level.

Laser micromachining is following this trend: with the ›microVEGA‹ model, Chemnitz company 3D-Micromac has already developed a platform for laser micromachining at wafer level. The system can process both 200 mm and 300 mm wafers, and impresses with outstanding throughput and exact process control. In order to do this, the microVEGA system is equipped with integrated measurement technology for continuous process control. The temperature is precisely controlled to ±0.1 K for maximum temperature stability.

Even more dynamics as target specification

During the course of a major investment of a well-known German chip manufacturer, the Chemnitz laser specialists were asked to design a system for the next generation of link trimming applications. The fact that the typical structure sizes in this application are around 1 to 2 µm required extremely precise, three-dimensional positioning and laser focusing and high-precision laser spot-to-structure alignment. »The quality and precision of the laser optic design is only half of the battle – high-precision and dynamic motion systems are also required,« emphasises Uwe Wagner, the CEO of 3D-Micromac. During the development of the new ›microVEGA FC‹ model, the main focus was therefore on completely redesigning the wafer positioning system in the size of 300 mm. As well as requiring positioning accuracy of < 100 nm and repeat accuracy of < 40 nm (3 Sigma), new optimum values were also required with regard to dynamics.

In close cooperation with the air bearing specialists from Eitzenberger, the choice fell on an air-suspended axis system. These have significant advantages in comparison to ball bearing systems, which are particularly evident in high-precision movement systems in semiconductor technology:

- No mechanical wear,
- No lubricant required,
- No stick-slip effect,
- Extremely quiet operation and accuracy,
- High dynamics with constant precision,
- Suitability for sensitive environments such as clean rooms and
- Less complexity than magnetic or hydrostatic bearings.

» The double pulse decoupling in the X and Y axes is something that is new on the market. «

Wolfram Meyer. Head of Sales and Business Development at Eitzenberger

The advantages of pulse decoupling

Particularly the characteristic of achieving high precision with extremely small step widths makes air bearing technology the number one choice. However, the dynamic drive forces generate oscillation, which interferes with the accuracy. This problem has been solved using pulse decoupling. Instead of introducing the reaction forces of the motors in the exact part of the machine, they are diverted into a reaction mass. However, diverting

Pictures: Eitzenberger (3, 4, 5)

Figure 3. ›microVega FC‹ laser micromachining system from 3D-Micromac: Even more dynamic in the latest version for link trimming on a 300 mm wafer

this force increases the mechanical complexity, which is why only unidirectional pulse-decoupled air bearing axes were previously available and established on the market.

However, the new generation of machines shouldn't just be state-of-the-art, as Wolfram Meyer, Head of International Sales and Business Development at Eitzenberger, emphasises: »Our ›dynamic wafer stage is a completely new system with twofold pulse decoupling in the X- and Y-axes – a new feature on the market which was presented for the first time at the Laser World of Photonics in Munich.«

Obstacles on the way to achieving the goal

The challenge of double pulse decoupling lies in the scaling. The reaction mass of an axis must be in a certain ratio to the moved mass of the axis. If the upper axis is decoupled in the conventional way, the lower axis does not only carry along the upper axis but the reaction mass of the upper axis. The lower axis then requires an even greater reaction mass. This situation is countered by the scaling of this system. It becomes accordingly difficult to achieve a high intrinsic frequency and good dynamics. Janis Wortmann, R&D Manager at Eitzenberger, explains: »The trick is that both axes use the same reaction mass. The lower axis does not have to carry along any of the reaction mass of the upper axis. The force path of the reaction forces remains independent of the metrology frame of the machine when doing this.«

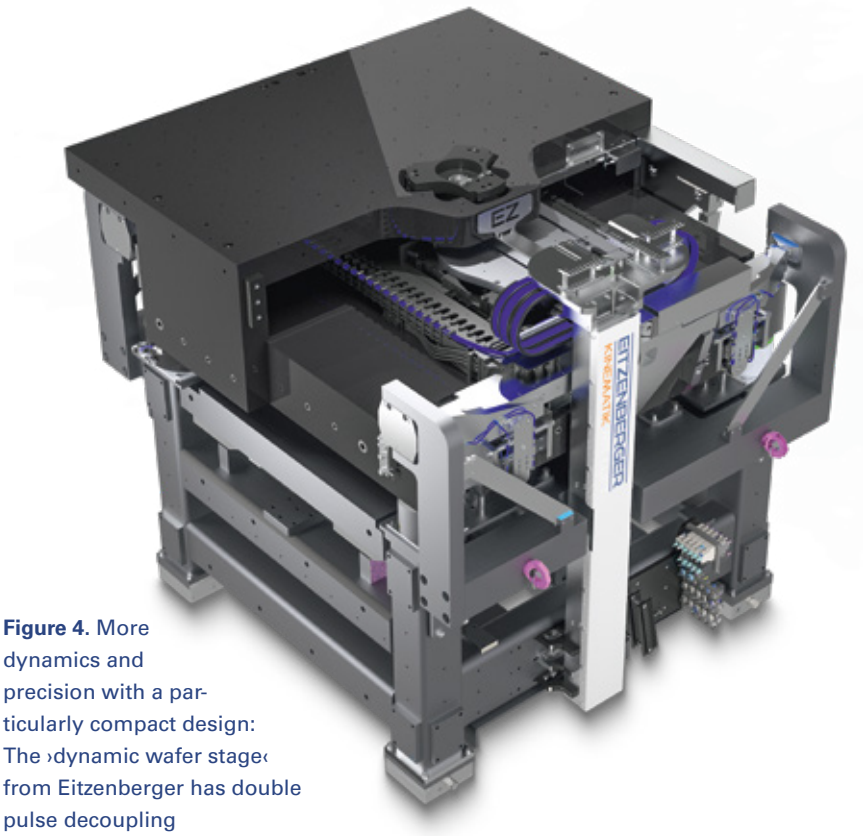

Figure 4. More dynamics and precision with a particularly compact design: The ›dynamic wafer stage‹ from Eitzenberger has double pulse decoupling

A well thought-out lightweight construction made from aluminium and GRP with a flat design connects the reaction mass with the stator of the Y-axis via air bearings. Thanks to this system, both axes can now fully utilise their dynamics without interfering with each other or the laser process. Another advantage: In spite of the usual working frequencies of 1 to 3 Hz, passive (floor) oscillation decoupling is sufficient. The resonances of these pneumatic springs are simply not stimulated. The systems which are otherwise needed in this dynamic class for granite stabilisation are not required.

Vacuum-groove bearings as the solution

However, the biggest step towards a particularly compact design was achieved using a technology that Wortmann describes as follows: »The outstanding new feature is that the axes are supported on integrated vacuum-groove bearings.« Unlike conventional, vacuum pre-loaded air bearings, this technology does not have a vacuum chamber for generating pre-loading. Instead, the entire bearing surface can generate positive and

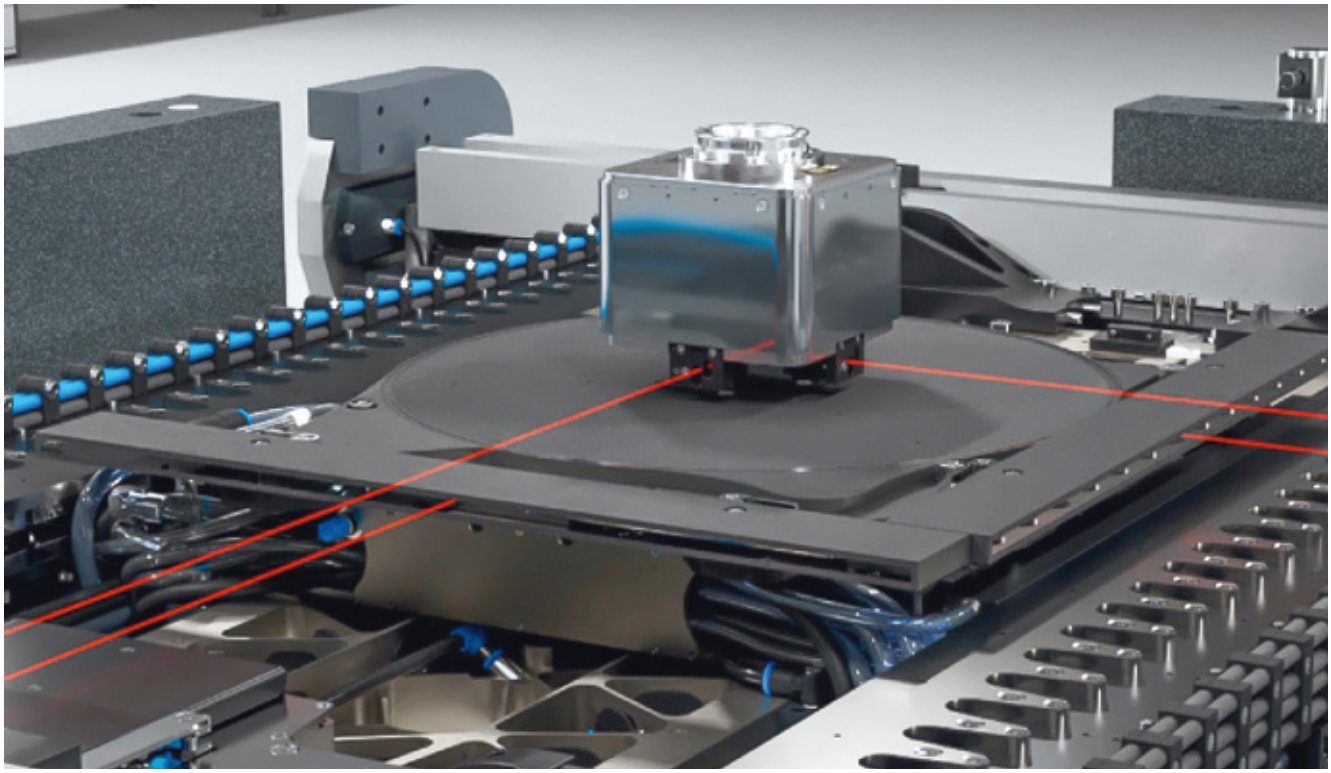

Figure 5. Difference interferometer in the dynamic wafer stage

negative pressure. »With the integrated vacuum-groove bearing, we can make the main rail significantly lighter, because we also make use of the stiffness of the stationary granite structure in moved parts«, explains Wortmann. The main rail can support itself on the granite, and does not have to be intrinsically stiff in every respect. The increase in stiffness directly from the granite structure does not increase the moved mass, which is a bonus with regard to the dynamics. »This is a completely new development from our company, and a world first,« explains the proud air bearing expert.

> »The outstanding new feature is that the axes are supported on vacuum-groove bearing.«
>
> **Janis Wortmann.**
> Janis Wortmann, R&D Manager at Eitzenberger

Extreme precision due to interferometer

The stage is equipped with the high-stability differential interferometers from SIOS with a resolution of 5 pm. These make it possible to have a design that is almost free of Abbé errors, and are integrated in the stage in such a way that the geometric deviations at the operating point with full dynamics are minimised. The challenge here was not the complexity of the interferometry, but the optical mirrors on the wafer chuck. »Following intensive global research and validation at Eitzenberger, this obstacle was also overcome,« reflects Wolfram Meyer.

Dynamic specifications exceeded

Air-mounted, co-planar XY-stages as a gantry have already been constructed at Eitzenberger. In the specific application, the main focus was on extremely rapid acceleration and dynamic accuracy for scanning processes. Consistent structure optimisation made it possible to shift the initial intrinsic frequency of the Y-axis including the wafer chuck to values beyond 500 Hz, which is an excellent result. The structural height of the wafer stage is also extremely compact at 87 mm. The acceleration capability in the Y-axis is also outstanding, with values of up to 8 g. Travel profiles with continuous acceleration of 2 g are possible by means of water cooling. The positioning accuracy target value could also be exceeded with values of ±100 nm. ■

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