#BREAKTHROUGH

MICROCHIPS ARE BECOMING *NANOCHIPS*

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PHOTOS: DEUTSCHER ZUKUNFTSPREIS, ANSGAR PUDENZ

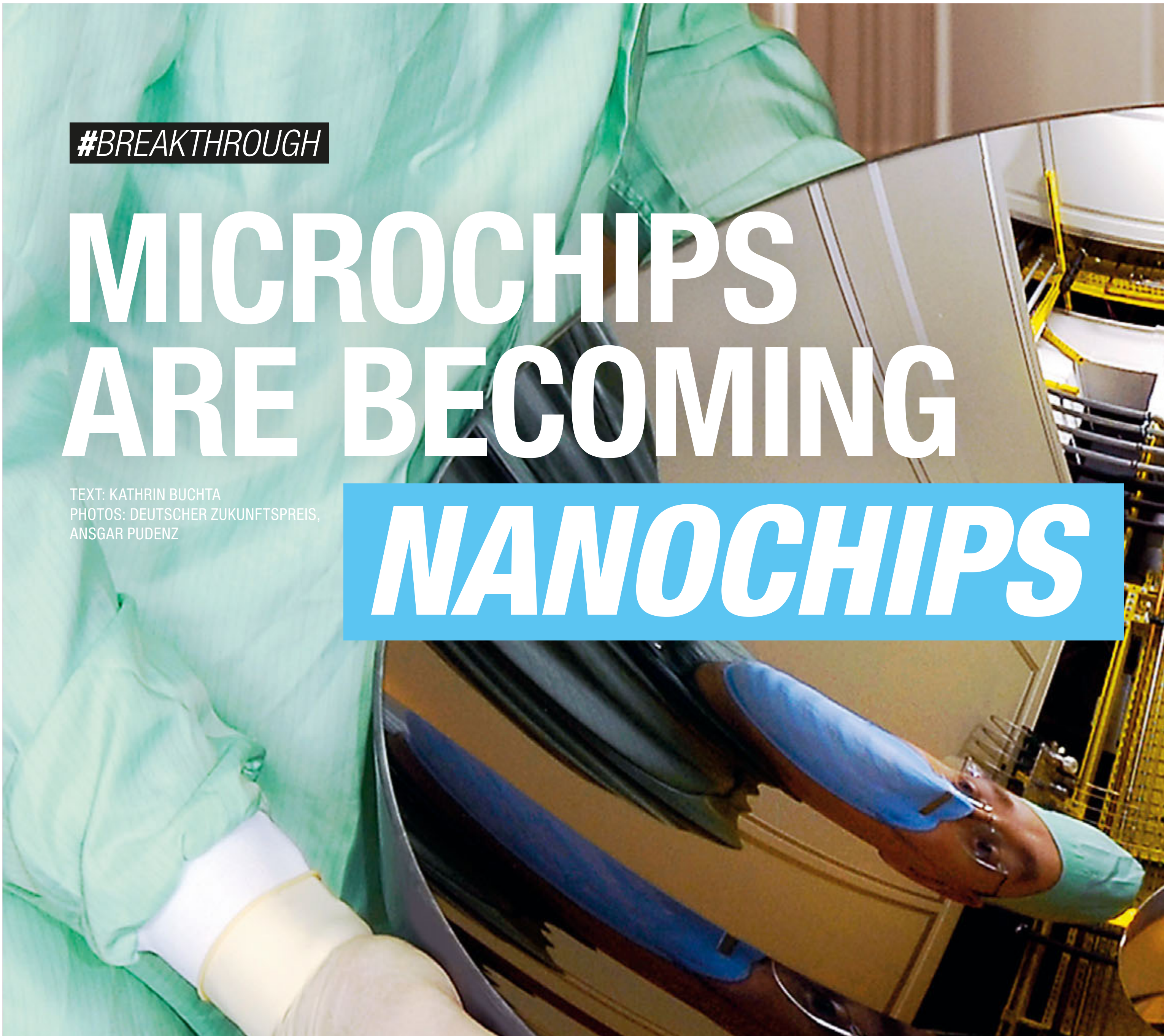
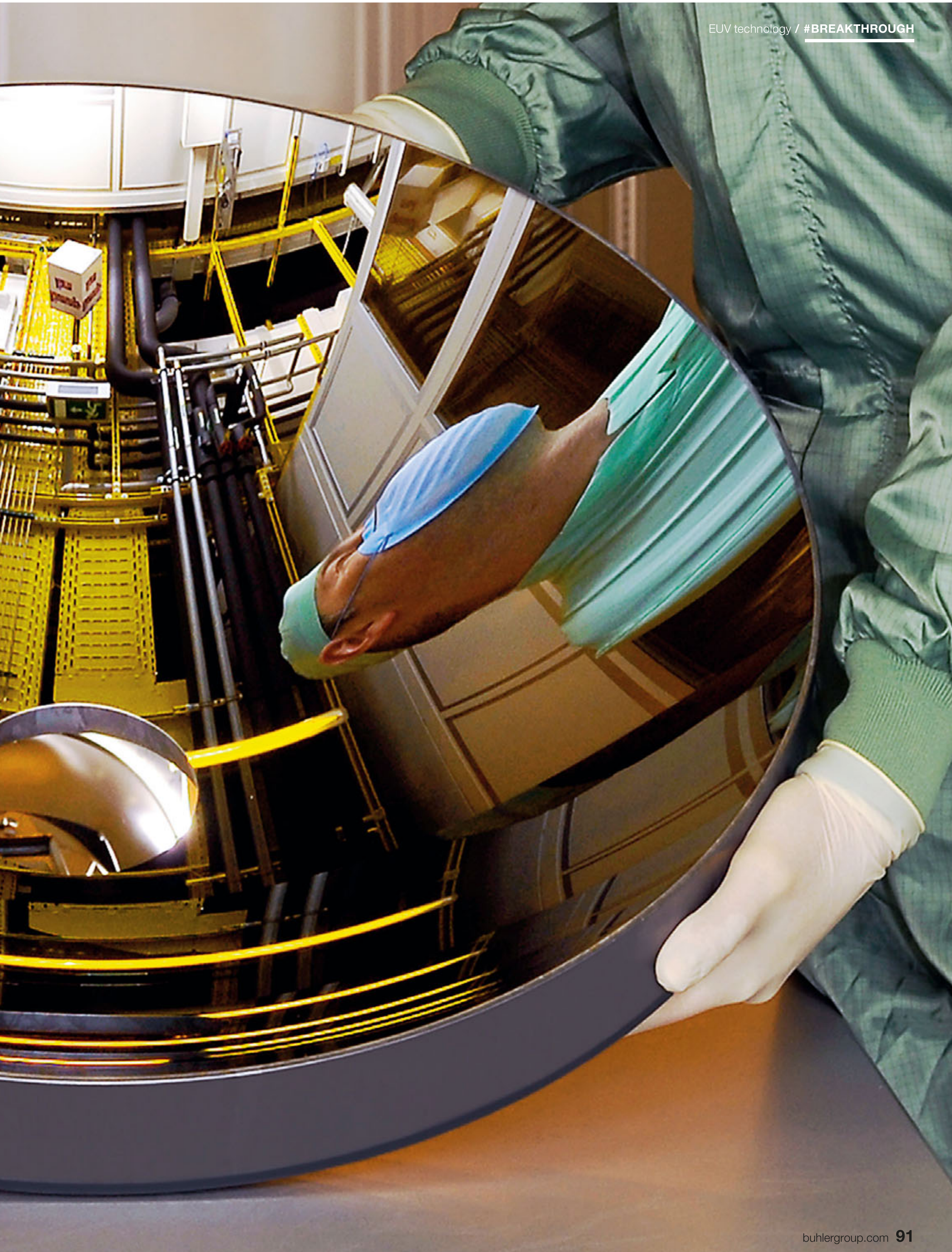


Image source: Deutscher Zukunftspreis, Ansgar Pudenz, Fraunhofer.

Everyone's talking about a new technology in the semiconductor industry – EUV lithography. It uses extremely short-wave ultraviolet light to produce microchips in the tiniest format that can process enormous quantities of data in computers and smartphones. Bühler is playing a role in this development.



The system for EUV lithography works in a high vacuum, because the extremely short wavelength ultraviolet light is absorbed by the air.

A RACE IS on in the semiconductor industry. It's a race to see who can produce the smallest and most efficient microchips in the world. The growing volumes of data that smartphones and other high-performance computers have to process simultaneously at an increasingly high speed requires the use of microchips whose performance reaches far beyond anything we have seen before. Whichever company is in the lead here determines how the industry will progress.

A breakthrough came last year. Thanks to EUV lithography, the production of such tiny microchips is now possible. EUV stands for "extreme ultraviolet" and refers to light with extremely short wavelengths. These lightwaves can be used to produce more powerful, energy-efficient, and cost-effective microchips. In contrast to the existing lithography, EUV can be used to create structures that are roughly one ten-thousandth of the thickness of a human hair.

Conventional systems won't do

The performance of microelectronics depends essentially on how many transistors (electronic semiconductor components) are packed into a particular area. This is a rapidly developing area of technology, especially since the packing density has doubled about every two years in the last 50 years, according to Moore's Law (see box).

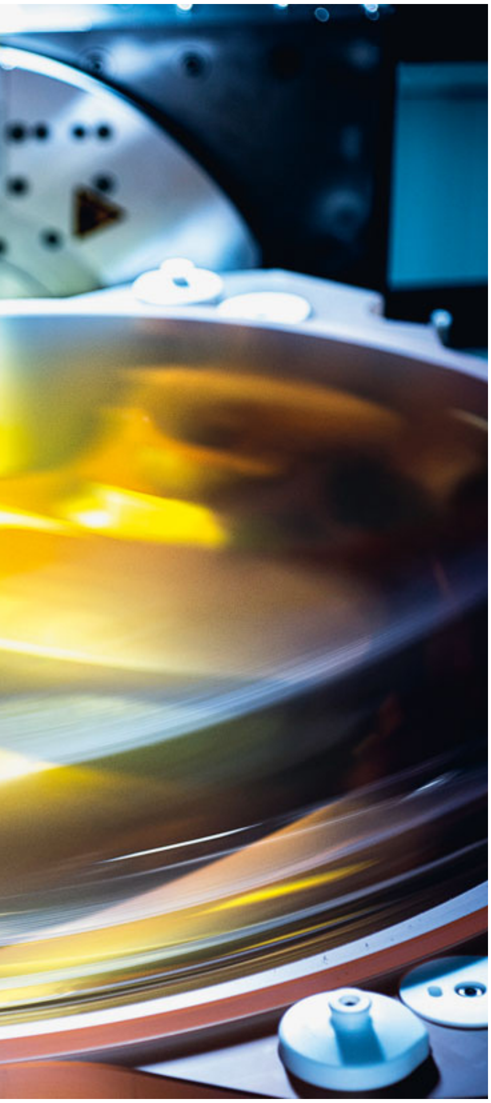
In recent years, optical lithography was increasingly reaching its physical limits. The leap to EUV lithography was necessary to realize semiconductor structures on the nanometer scale. However, this step required an entirely new way of thinking about how production processes should run. The entire technology, from the light source to the optical system in a vacuum to the surface coating, had to be developed from scratch.

Extreme ultraviolet light is absorbed by air, making it unsuitable for use in conventional production environments. Moreover, this light cannot be shaped and focused by lenses which is the common practice in optical lithography. To avoid this physical problem, researchers at Carl Zeiss SMT have developed a lithographic system consisting exclusively of mirrors. It is adapted for use in a high vacuum, for example, in an environment with almost no air molecules. The mirrors used in this technology must meet extremely high requirements. The requirements for the mirror layers are equally high. They consist of approximately 100 individual layers that are applied with atomic precision. A further decisive factor is that the mirrors need to have a diameter of more than half a meter to make it work.

The Fraunhofer Institute for Applied Optics and Precision Engineering IOF, based in Jena, Germany, is a long-standing customer of Bühler Leybold Optics and one of the key partners in the development of this mirror coating.

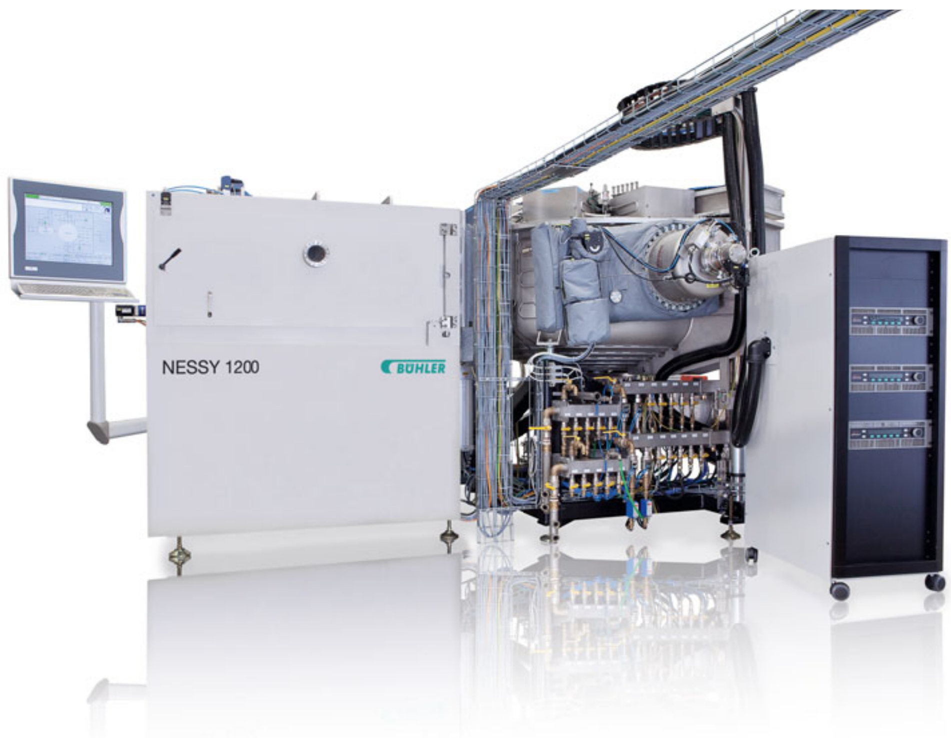
Finding NESSY

Dr. Sergiy Yulin has been undertaking research at Fraunhofer IOF for over 20 years on the utilization of extremely short-wave light for lithographic production of microchips. At the beginning of his research, there were no coating systems capable of applying layers with the necessary precision to the required large mirror substrates. Over time, however, it turned out that the Bühler Leybold Optics' NESSY system made this process possible. In 2009, the Fraunhofer IOF succeeded in producing an EUV mirror with a diameter of 66 cm with the NESSY 2



“WE HAD TO RETHINK AND DEVELOP COATING SOURCES AND DRIVE TECHNOLOGY IN A VACUUM ENVIRONMENT.”

KLAUS HERBIG
Head of Product Management at Bühler Leybold Optics



The NESSY from Bühler Leybold Optics makes it possible to coat EUV mirrors with a diameter of over half a meter.

– an outstanding achievement at the time. Today, the NESSY system is already in its third generation and is used by a number of clients for mirror coating.

Rethinking and redeveloping

“When Fraunhofer IOF reached out to us in 2002 with their requirement for precision on large curved substrates, it initially seemed impossible to produce such results. Their requirements for mechanical engineering and process technology had not yet been implemented by any company in the world,” explains Klaus Herbig, Head of Product Management at Bühler Leybold Optics. “We had to rethink and develop coating sources and drive technology in a vacuum environment.”

After approximately 20 years of research and development, the technology is now ready for the market and available for use in the semiconductor

INFO

Moore’s Law was established in 1965 by the American Gordon Moore, co-founder of Intel. The law states that the number of integrated circuits that can fit on a microchip doubles at intervals of approximately two years at minimal cost.

The winning team of experts (from left): Dr. Sergiy Yulin of the Fraunhofer IOF, Dr. Peter Kürz of Carl Zeiss SMT, and Dr. Michael Kösters of Trumpf Lasersystems.

"I THINK LEYBOLD OPTICS FOUND US VERY CHALLENGING AT TIMES, BUT IN THE END THIS WAS THE KEY TO THE BREAKTHROUGH AND BOTH SIDES LEARNED A GREAT DEAL."

DR. SERGIY YULIN
Fraunhofer Institute for Applied Optics and Precision Engineering IOF

INFO

Optical lithography has been the key technology for microchip production for over 40 years. Previous processes used a light source with a wavelength of 193 nanometers. EUV lithography is a photolithography process that uses electromagnetic radiation with a wavelength of 13.5 nanometers, known as extreme ultraviolet radiation. This should make it possible to continue the structural reduction in the semiconductor industry in the future and to produce smaller, faster, and more efficient integrated circuits. The principle here is that the shorter the wavelength of the light, the smaller the structures that can be produced.

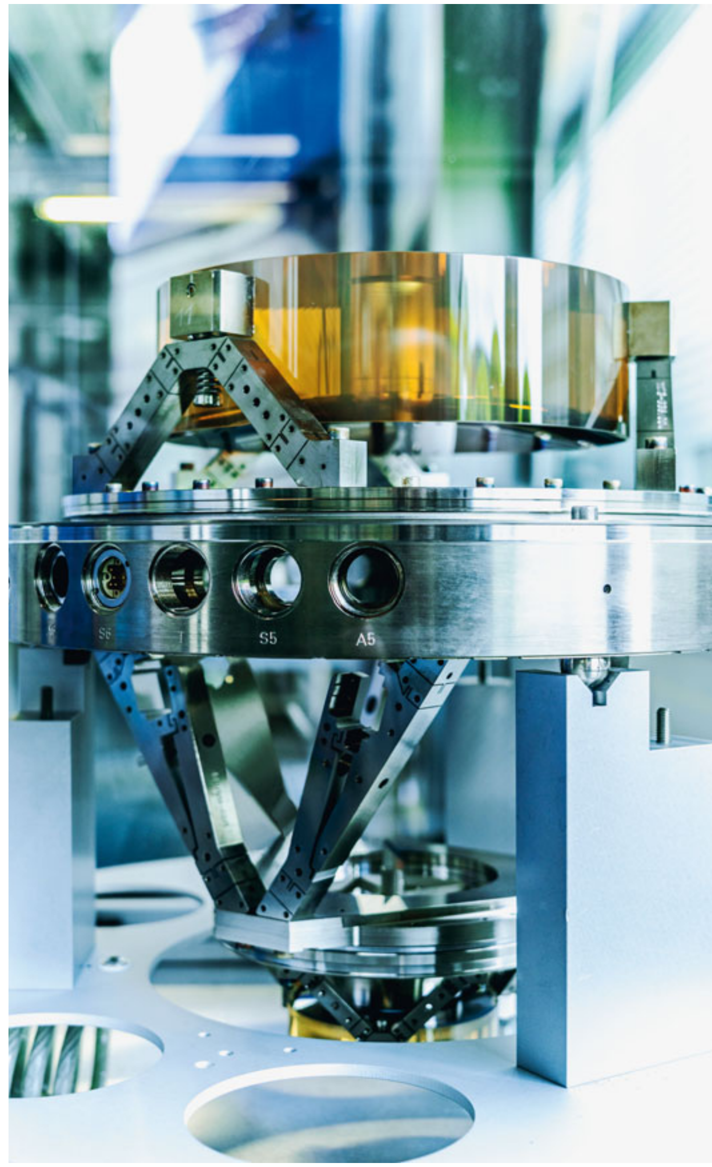
industry. By the end of 2020, it is expected that around 90 EUV lithography systems will be delivered around the world. The two biggest microchip manufacturers in the world, Samsung from South Korea, along with TSMC from Taiwan, already use them to produce logic chips of the latest generation.

Leading the way through collaboration

This innovation opens up enormous economic potential in a market with annual global sales of tens of billions of dollars. It is not only ZEISS and TRUMPF that will benefit from this development of EUV lithography, which is secured by more than 2,000 patents. It has already created several thousand high-quality new jobs as a large network of companies and research institutes in Germany and Europe that are involved in the project as suppliers or scientific partners.

EUV lithography will lead the way for the semiconductor industry in the coming years. This is also reflected in the fact that the renowned German Future Prize, the Federal President's Prize for Technology and Innovation, was awarded in November 2020 to a team that has made a significant contribution to the development of EUV tech-

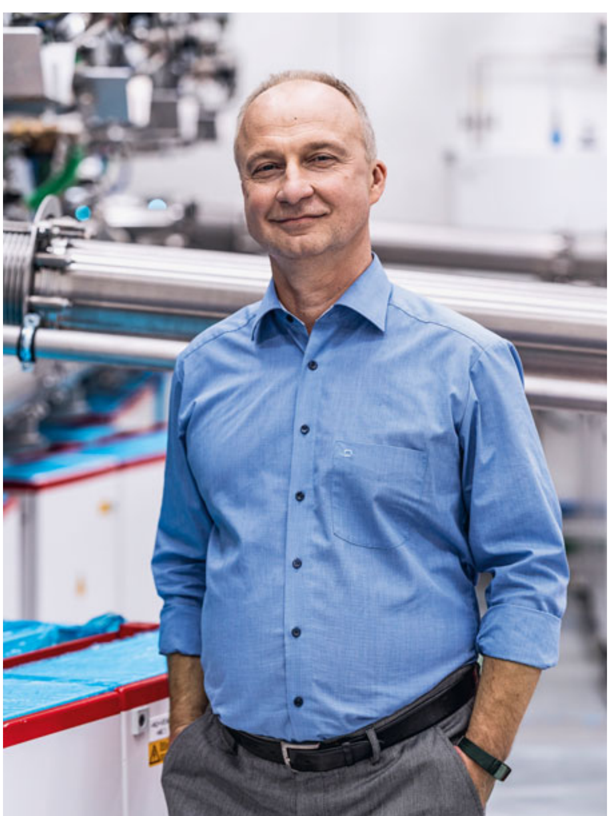
A core element of the system for the EUV lithography is a lens which is integrated into the EUV Micro Exposure Tool.



nology. The team of experts consists of Dr. Peter Kürz of Carl Zeiss SMT, Dr. Michael Kösters of Trumpf Lasersystems, and Dr. Sergiy Yulin of Fraunhofer IOF. Together, they have developed a system for EUV lithography in which they also used coating systems supplied by Bühler Leybold Optics.

Winning the German Future Prize is a recognition of the many years of good cooperation between all those involved, says Dr. Steffen Runkel, Head of Optics at Bühler. “Even unforeseeable hurdles and challenges that arise on the way to marketability of a solution where many have failed worldwide can be overcome with the strengths of the collaboration partners and sufficient perseverance.”

Dr. Sergiy Yulin of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF.



INTERVIEW

Read the interview with Dr. Sergiy Yulin of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF. This scientist was significantly involved in the development of a system for EUV lithography. He and his colleagues won the 2020 German Future Prize.

WEBSITE

On the 2020 German Future Prize website, you will find more information about the winning team from ZEISS, TRUMPF, and Fraunhofer IOF. The German Federal President’s Prize for Technology and Innovation is awarded annually at the end of November.