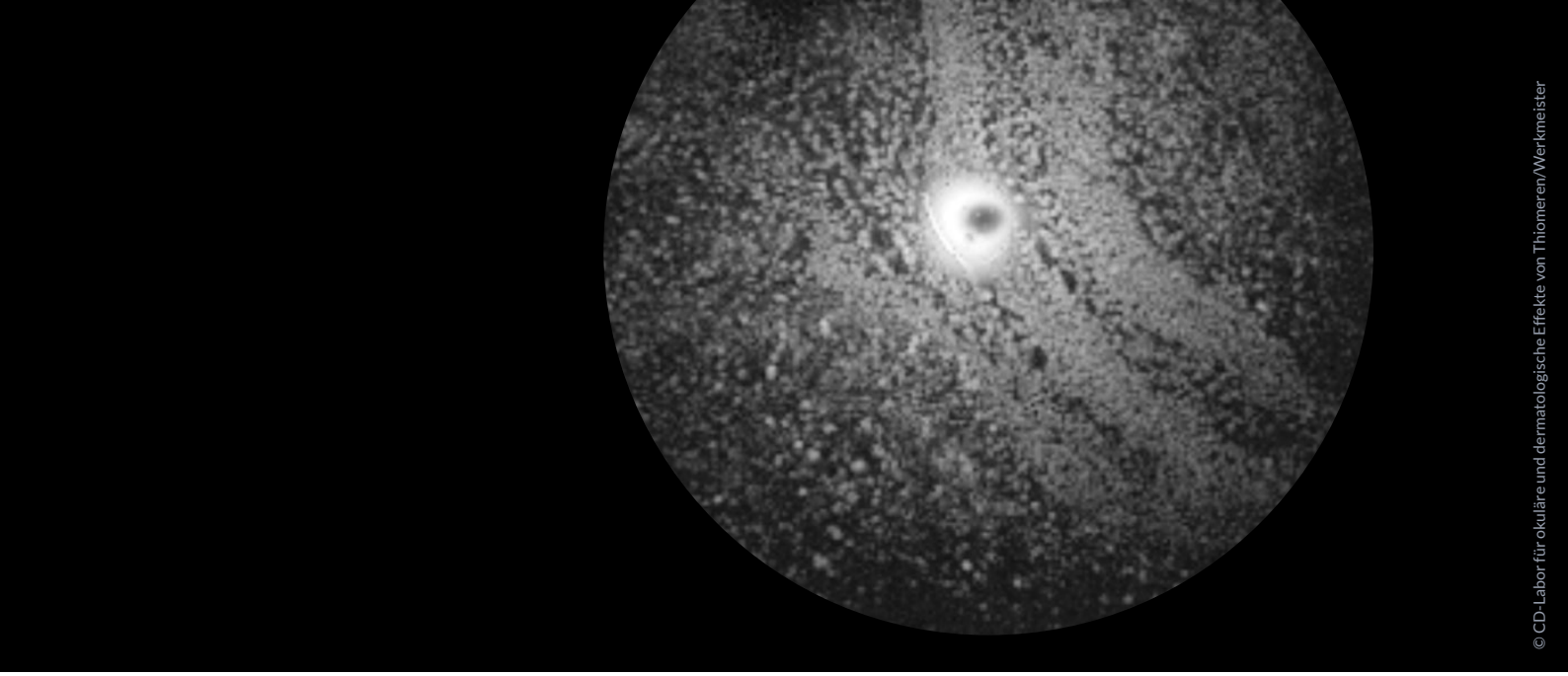

Federal Ministry
Economy, Energy
and Tourism
Republic of Austria

What eye examinations have to do with the Nobel Prize

Before the scientific breakthrough of the attosecond laser, Nobel Prize winner Ferenc Krausz initially worked on laser flashes lasting just a few femtoseconds. Several CD Laboratories were involved in developing these technologies for Medicine.

What is at issue

In the early 1990s, there was a spirit of optimism in ultra-short pulse laser physics. Scientists succeeded in generating ever shorter laser pulses, initially in the femtosecond range (10^{-15}s). It soon became clear that ever shorter pulses would enable the observation of ever faster processes, such as elementary processes in chemical reactions, for which Ahmed Zewail received the 1999 Nobel Prize in Chemistry. Ultimately, the quest for increasingly shorter laser flashes led to the unimaginably short attosecond range (10^{-18}s): The groundbreaking experiment was carried out in 2001 at the Vienna University of Technology by Ferenc Krausz, winner of the 2023 Nobel Prize in Physics. These lasers can be used to observe exactly what happens when one or more electrons are ionized from an atom.

OCT: Femtolasers and their potential in Medicine

In the 1990s, Ferenc Krausz just dreamed of attosecond lasers. He and his research group ultimately solved key problems in laser technology using special mirrors (chirped mirrors) and titanium sapphire lasers. Eventually, they achieved 12 femtoseconds. Wolfgang Drexler, head of the CD Laboratory for CD Laser Development and their Application in Medicine, recognised the opportunities these lasers offered for Medicine. The shorter the laser pulse, the broader the range of wavelengths the laser beam contains. And the greater this wavelength bandwidth, the greater the resolution of a device that can now be found in almost

CD Laboratory for Laser Development and their Application in Medicine I and II

Head
Univ.Prof. DI Dr. Wolfgang Drexler

Duration
01.04.2002 – 30.06.2006 and
01.01.2011 – 31.12.2013
Phasing out period
01.01.2014 – 31.12.2014

Commercial partners
Carl Zeiss Meditec AG, Croma-Pharma Gesellschaft m.b.H., FEMTOLASERS Produktions GmbH, Imedos Systems UG

CD Laboratory for Ocular and Dermal Effects of Thiomers

Head
Univ.Prof. DI Dr. Leopold Schmetterer (until 2016) and Assoz.Prof. DI (FH) René Werkmeister, PhD (since 2017)

Duration
01.01.2014 – 31.12.2020
Phasing out period
01.01.2021 – 31.05.2021

Commercial partners
Carl Zeiss Meditec Inc, Croma-Pharma Gesellschaft m.b.H.

Three questions for …

Andreas Assion
Sr. Manager Engineering
bei MKS Instruments

How did your company benefit from participating in the CD Laboratory?
As is often the case in basic research, the side effects of the CD Laboratory were particularly important, in this case the scientific basis for the further development of oscillators for ultra-short pulse technology and thus for research in the field of attosecond lasers. The company has now withdrawn from the development of OCT devices due to a strategic realignment.

Is there still a connection between your current products and the research conducted at the CD Laboratory?
The Femtopower amplifier was launched on the market in 2001 as a product of FEMTOLASERS, further developed, and in 2005 the first systems with carrier envelope phase stabilisation (CEP) were delivered. These are the amplifiers that can be used to generate attosecond pulses. The Femtopower CEP systems are still being produced at the Vienna site today, even after the takeover by MKS. In 2024, the further development of CEP technology will be completed in collaboration with our colleagues at the Milpitas/California site.

What did you find particularly positive about the CD Laboratory funding model?
Especially for a relatively small, fast-growing company like FEMTOLASERS was at the time, close collaboration with the scientific community offers decisive advantages in terms of market competitiveness. The CD model is a big plus for innovative smaller companies in Austria.

every ophthalmologist's practice: optical coherence tomography (OCT), which is used for the early detection and treatment of retinal diseases. An OCT device works in a similar way to ultrasound, except that it uses light instead of sound. This allows for a completely contactless examination. The light can penetrate 2–3 mm less deeply than sound, but – depending on the bandwidth – it provides greater resolution. The advantage of OCT is its high resolution in the micrometre range, while its disadvantage is its low penetration depth. The eye is particularly suitable for this purpose because it is both transparent and small. Among other things, the CD Laboratory focused on examining the retina, which can be completely imaged with OCT due to its thinness (250–300 micrometres).

Cooperation in the CD Laboratory
The CD Laboratory's commercial partner was a spin-off company founded by scientists at TU Wien, including Ferenc Krausz: FEMTOLASERS Produktions GmbH. The company was founded in 1994 and produced laser systems based on the results of Krausz's research. However, a powerful femtolaser alone is not enough to make an OCT device. The task of the CD Laboratory was therefore to make the new technology usable for medicine: mirrors, light sources, variability of the wavelengths used, more compact design and repeated tests to ensure reliability. The CD Laboratory was able to demonstrate that the device works and produces images that are needed in medical practice. Since then, these devices have been further developed and have become significantly more cost-effective. The successors to the original prototypes are now used to assist in the diagnosis and treatment of retinal diseases.

And today?
Four other CD Laboratories at MedUni Vienna have previously focused on various aspects of OCT. In the CD Laboratory for Ocular and Dermatological effects of Thiomers, which was active until 2021, the focus was already on the application of OCT, in particular for the detailed examination of the tear film on the eye. Work on the light source was no longer carried out in this laboratory. Instead, the focus was on adapting of the detector unit, optics and optomechanics (mirrors and lenses) as well as on applying machine learning for the temporal optimisation of data analysis.

Scientific challenges

Wolfgang Drexler's CD Laboratory wanted to adapt the laser system developed by Ferenc Krausz for OCT applications. One research topic, for example, was the optical coating of mirrors. Significant progress was made in the development of a laser system with low power and high bandwidth – and thus sufficient resolution. The results showed that OCT can be a routine clinical imaging procedure in ophthalmology.

Added value for the company

The company FEMTOLASERS was co-founded by the current Nobel Prize winner Ferenc Krausz and is now part of MKS Instruments. Wolfgang Drexler's CD Laboratory conducted research into optimising the oscillators and amplifiers contained in the laser systems for OCT. This knowledge was incorporated into the development of oscillators and amplifiers that are now used in science, for example in research into molecules and atoms. Large oscillators/amplifiers are developed and manufactured for attosecond research. Customers are primarily universities and research institutes in Europe and Asia.

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