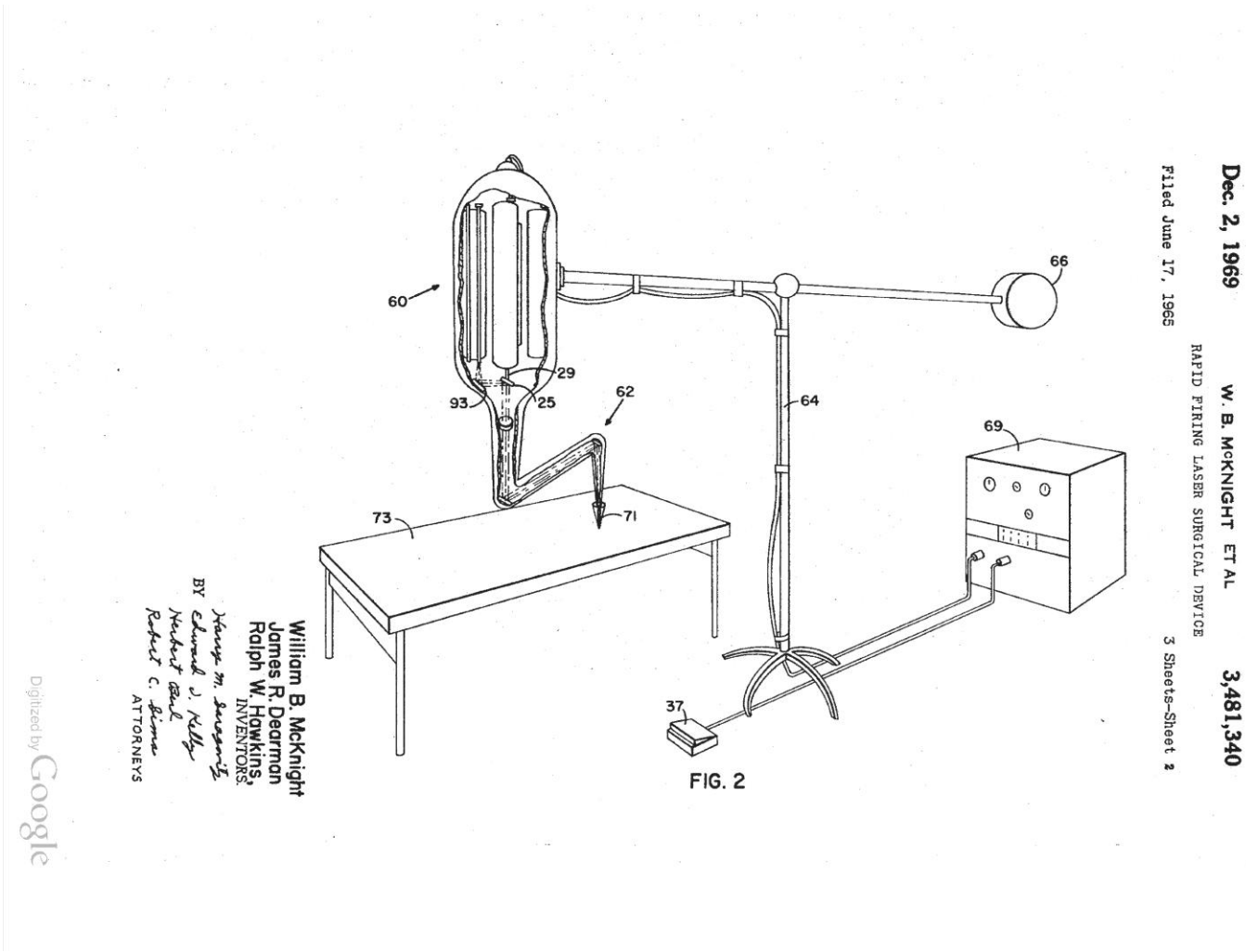
Femto-Lasers in Ophthalmic Systems

Dr. Christian Rathjen

Biomedical photonics network & Swisslaser.net annual meeting, Bern , 3. 11. 2010

HI-TECH INNOVATION EYECARE MADE IN SWITZERLAND

A first vision of a rapid firing surgical laser (~50 years ago).



Dec. 2, 1969 W. B. McKNIGHT ET AL 3,481,340

RAPID FIRING LASER SURGICAL DEVICE

Filed June 17, 1965 3 Sheets-Sheet 2

FIG. 2

William B. McKnight
James R. Dearman
Ralph W. Hawkins,
INVENTORS.

BY Harry M. Saragovitz
Edward J. Kelly
Herbert Berl
Robert C. Kline
ATTORNEYS

50 years later with a few minor modifications

ZIEMER GROUP at a glance

- Founded 1999: focused on Ophthalmology
- Currently 160 employees
- Headquarters in Port/Biel (CH), subsidiary in USA
- Global distribution network in 45 countries

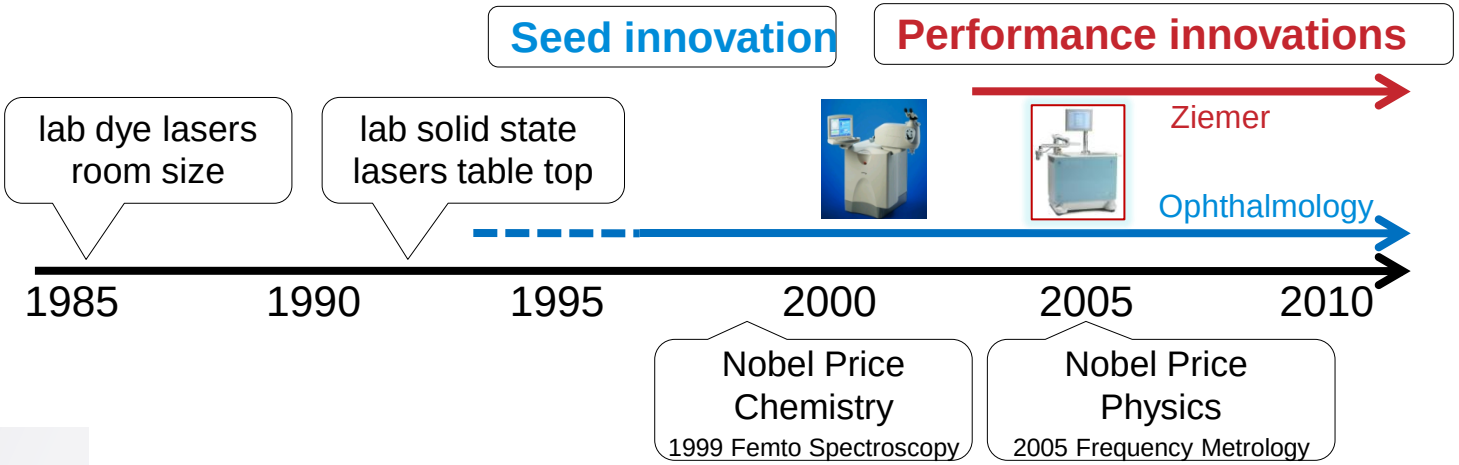
What ZIEMER offers

- Ophthalmic Products
  - Surgical
  - Diagnostics
  - Sterile Consumables
  - Product development
  - Contract manufacturing

- Competence and Skills
  - Micro-electronics, micro-mechanics, optics, opto-electronics, laser technology, hard/software, polymer technology, regulatory affairs, medical applications Know-how, system-assembly, marketing and sales
  - Extensive development and manufacturing network
  - Integral Innovation Management:
    From inventions to production into international markets

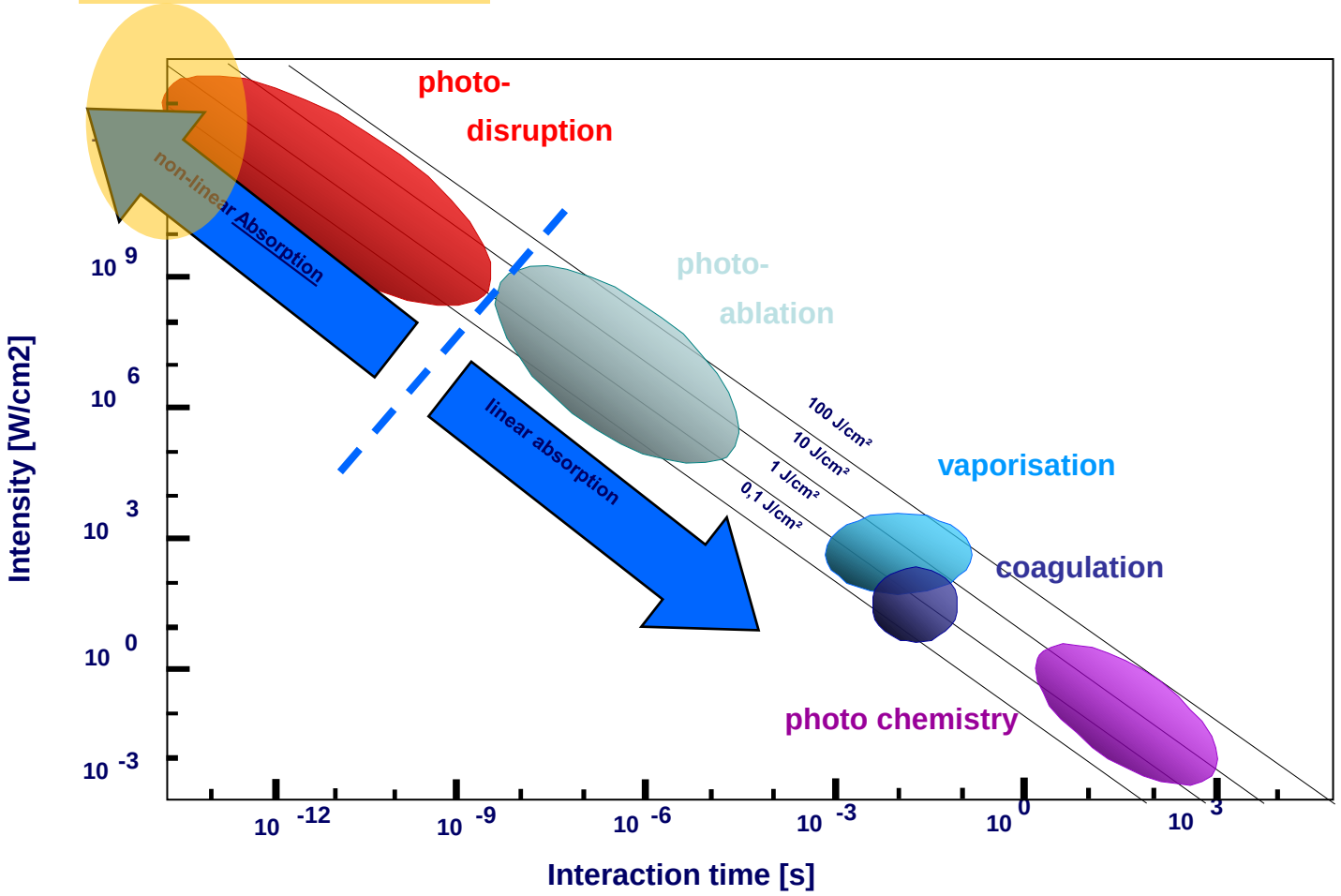
About Femtosecond Lasers

- **Pulsed Laser** with a pulse width measured in femtoseconds
- A femtosecond **fs**
  - fs = 10-15 s = 0,000.000.000.000.001 s
    A second divided by a million divided by a billions
  - Within a fs light travels only 0.3 mm
- Applications
  - Tools for fundamental research in physics and chemistry
  - Light sources for imaging instruments (OCT, microscopes)
  - Precision metrology
  - Ophthalmology (first application on **industrial scale**)
  - Precision machining (maturing)



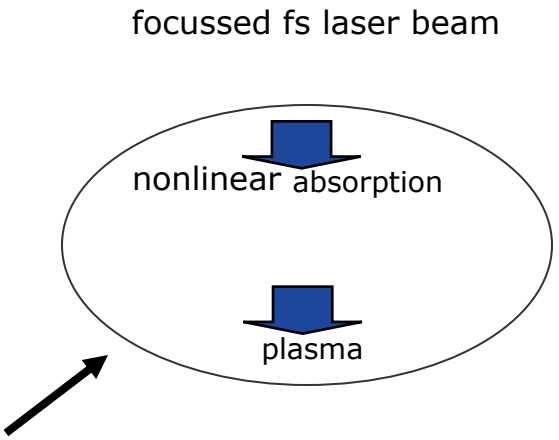
Interaction of laser radiation with bio. tissue

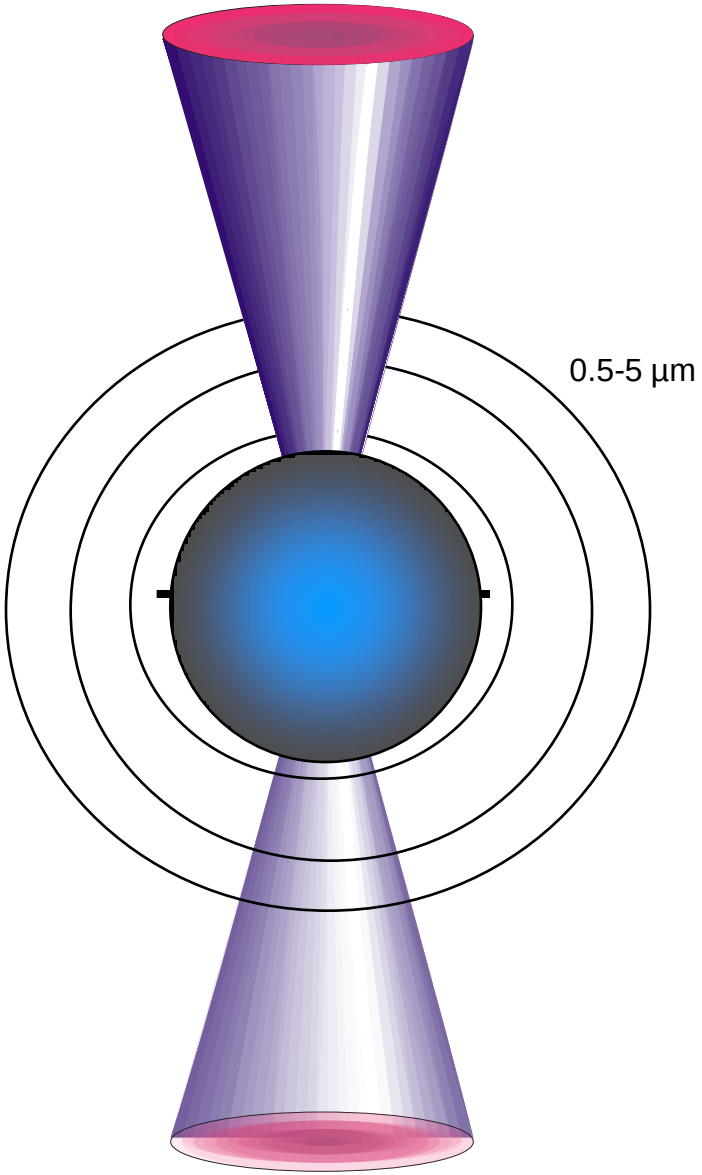
Femto second lasers



Source: H. Lubatschowski

Photo disruption process



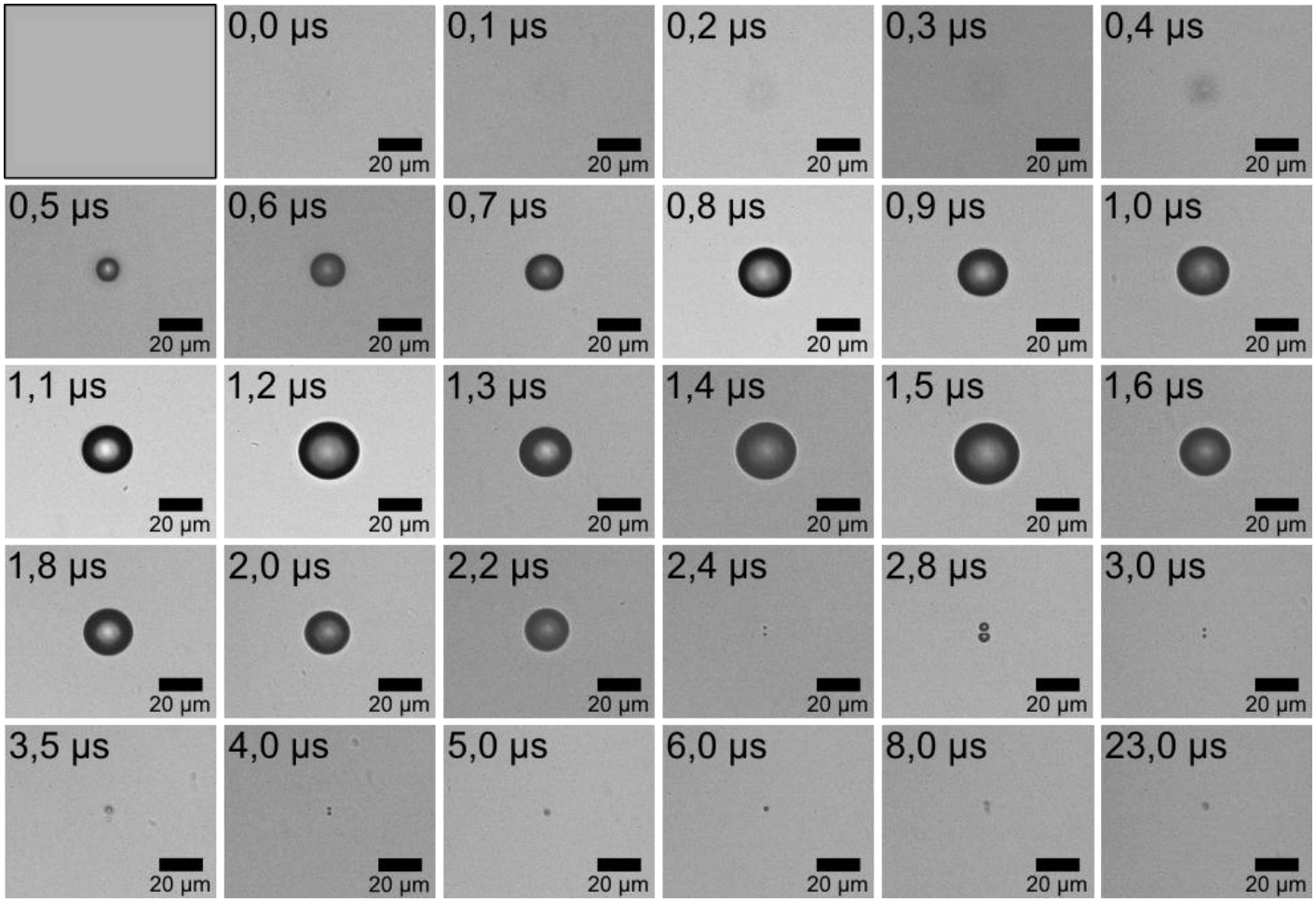


Very complex Physics:

Multi photon absorption,
impact/cascade ionization,
thermal ionization,
~~electron recombination,~~
~~electron diffusion,~~
…

Source: H. Lubatschowski

Bubble formation in water



Source: H. Lubatschowski

Competitive landscape in Corneal Surgery

Abbott Medical Optics

Ziemer
Femto LDV®

Alcon
Wavelight®

Alcon

Technolas Perfect Vision **FEMTEC ®**

Bausch & Lomb

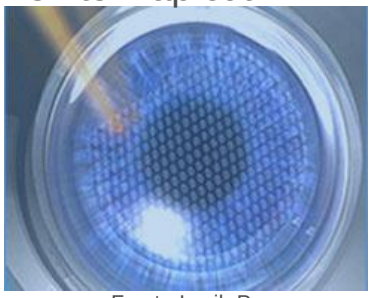
Zeiss Meditech
VisuMax ®

ZEISS CARL ZEISS MEDITEC

Application in Ophthalmology

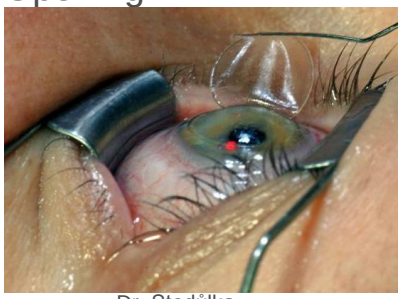
Most popular example **Femto-LASIK**: a **two laser process**

Femto Flap cut



Femto-Lasik-Pro

Opening



Dr. Stodůlka

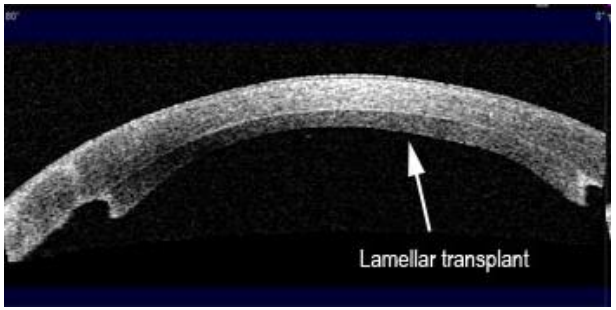
Excimer surface ablation

Ziemer Innovation

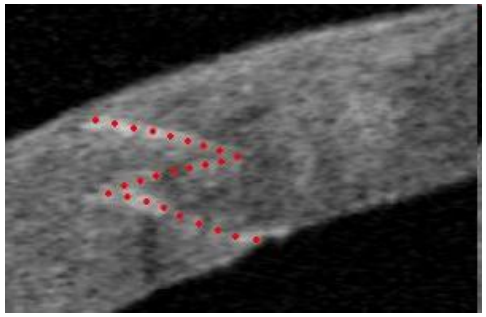
1. Handheld laser applicator
2. Full integration into LASIK workflow
3. No additional investments in infrastructure

Further Corneal Applications

- Corneal transplants (Keratoplasty)

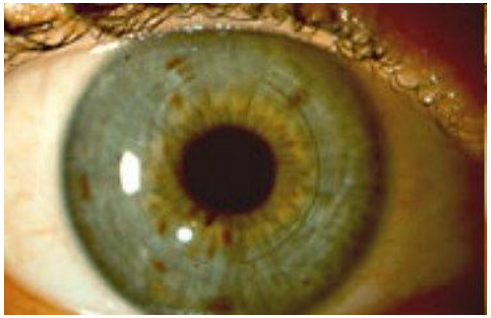


Manchester Royal Eye Hospital

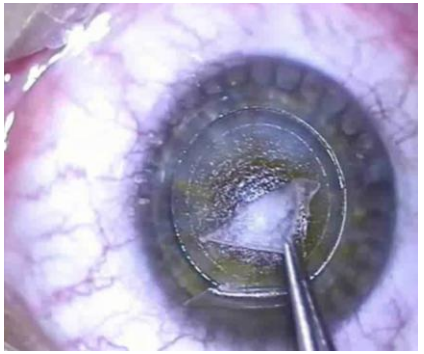


"IntraLase Enabled Keratoplasty (IEK)"

- Implants



- Visual correction



FLEx (**F**emtosecond **L**enticule **Ex**traction)
by Zeiss VisuMax®

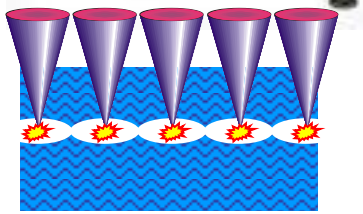
More innovations from Ziemer

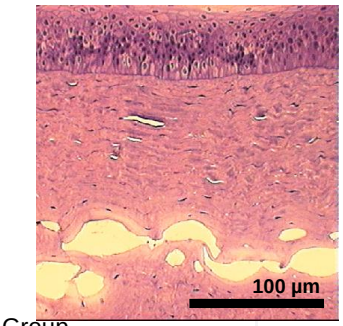
AMO iFS

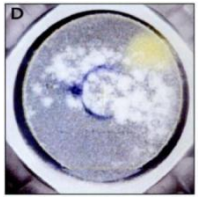
Ziemer LDV CrystalLine

Ziemer Innovation

4. Robustness
5. Mobility
6. Turnkey operation
7. New laser physics: high repetition rate, low pulse energy
   - No tissue bridges
   - Little to no gas production
   - Minimal side effects
     - No Transient light sensitivity
     - No OBL
     - No DLK
   - Fast visual recovery

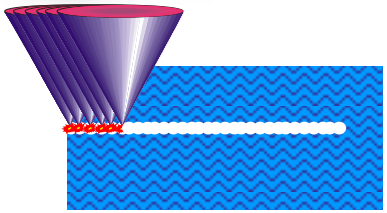


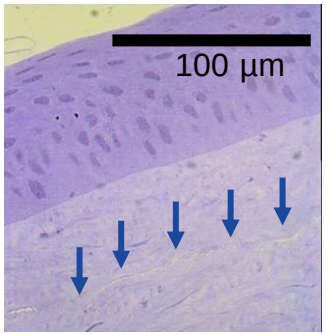




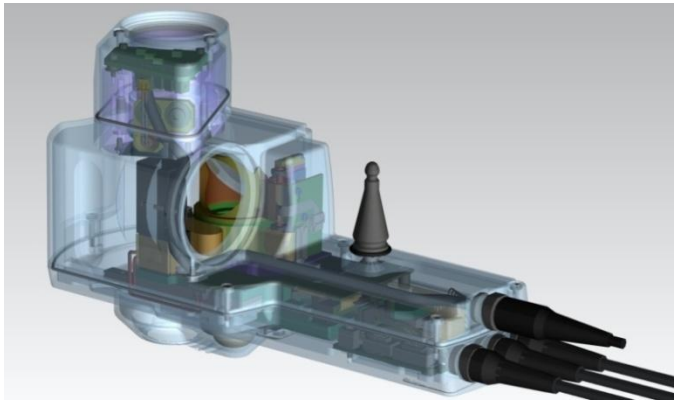
µJ & kHz

nJ & MHz

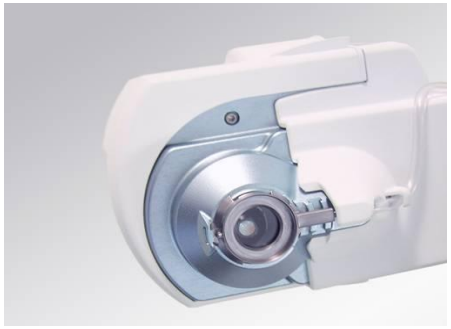


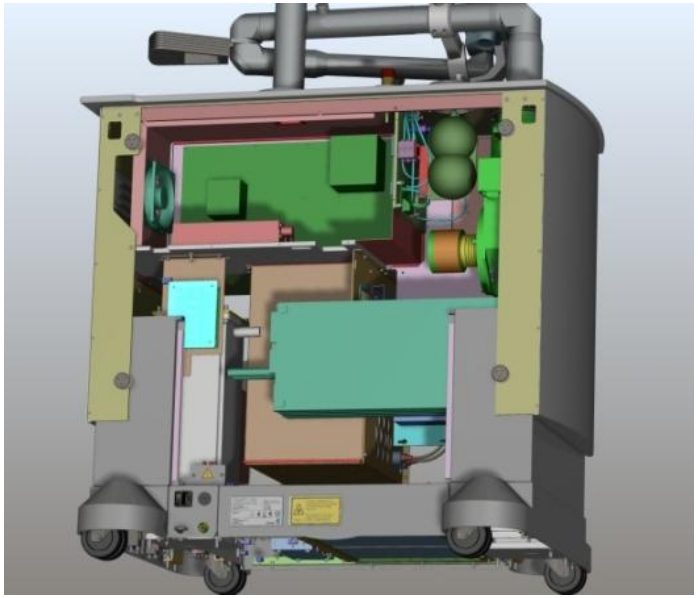


Ziemer Femto Technology



- Hand piece
  - Optics
  - Scanner
  - Camera
  - Electronics



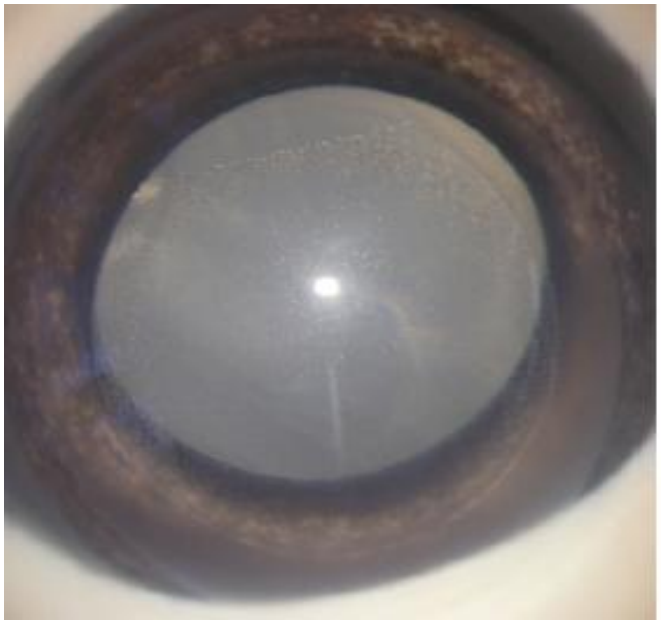


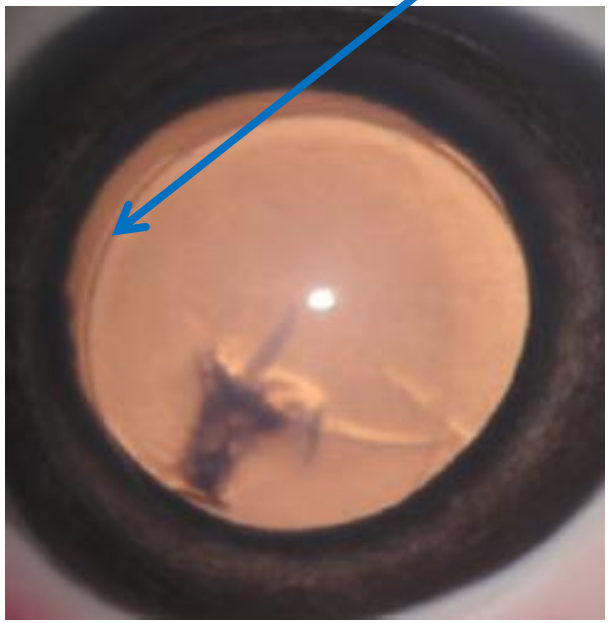
- Articulated arm
- Base station
  - Custom made laser
  - High speed scanner
  - Height adjustable
  - Custom made electronics and safety system

Our latest technology

- Crystal tuning
  - CrystalPlus procedure (improved edges & better lifting)
  - Reduced gas production (left picture)
  - No gas production at all (right picture)

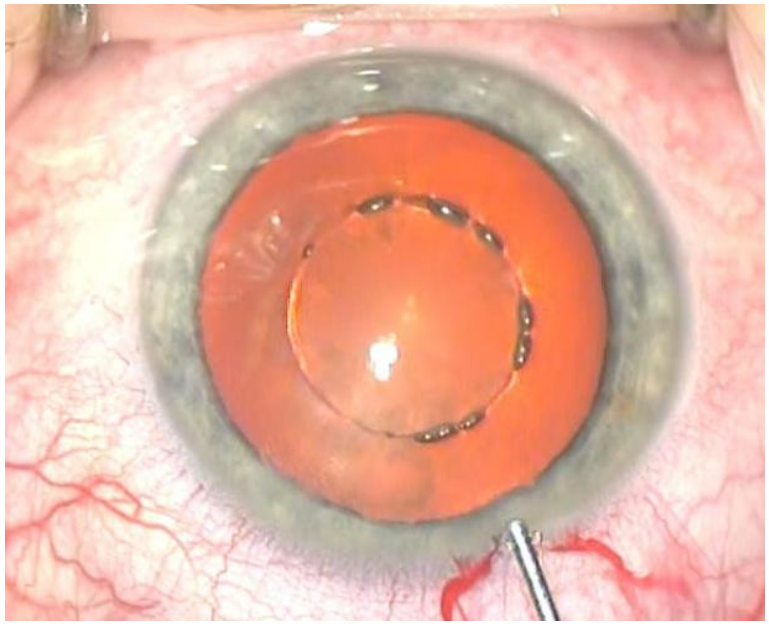
Lab experiments with CrystalLine machines:



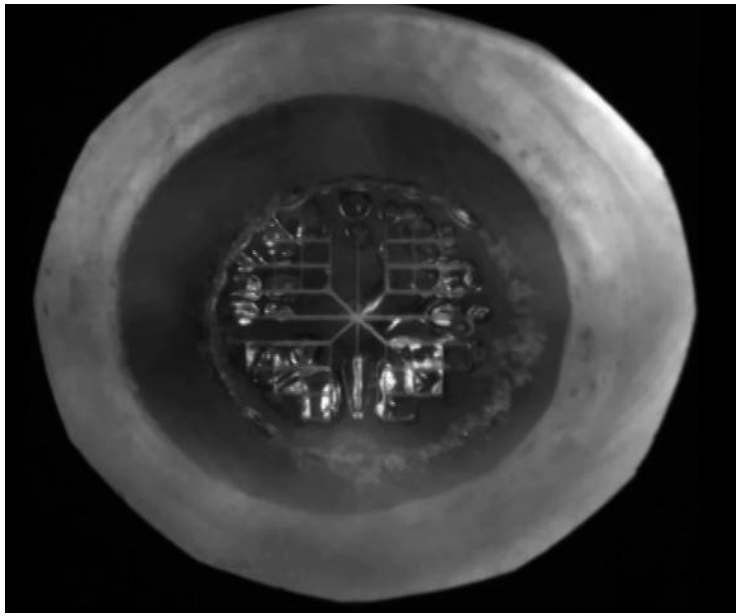


Cataract surgery

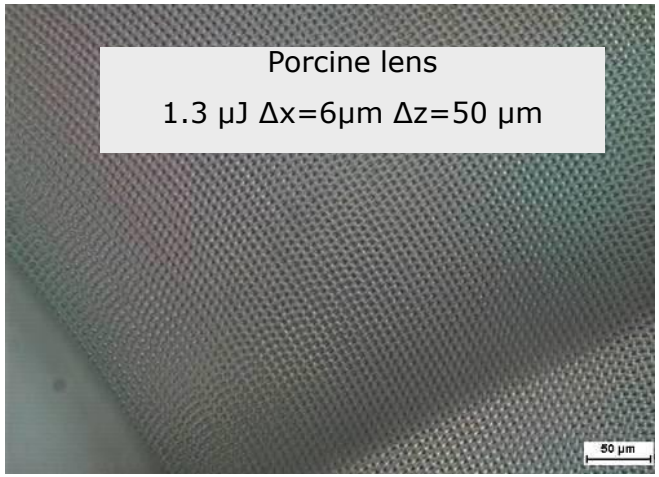
- Opening of capsular bag (Capsulotomy)

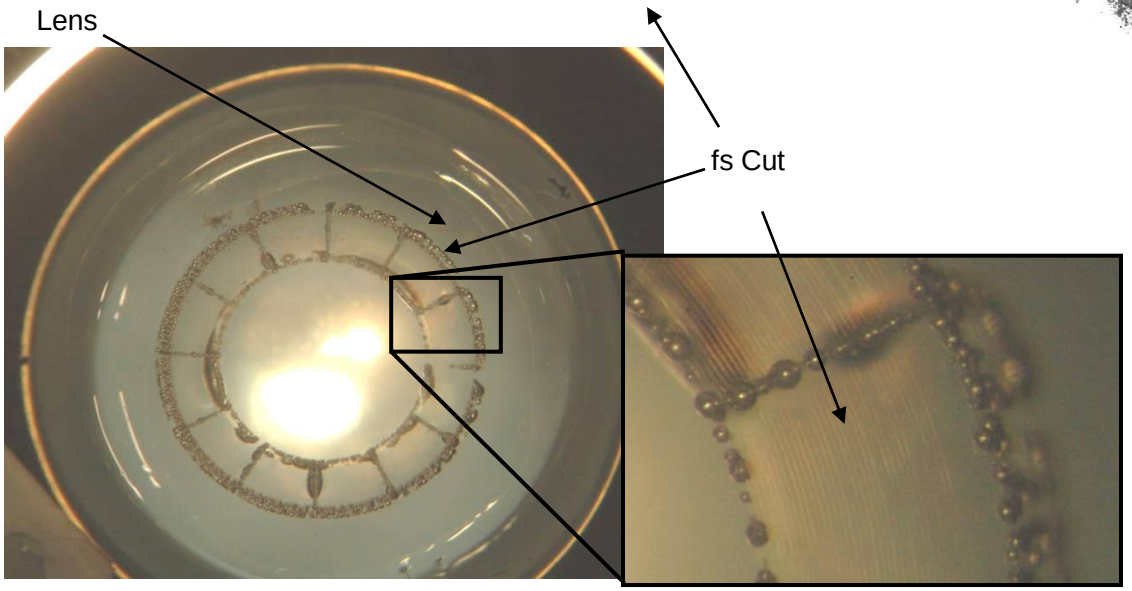


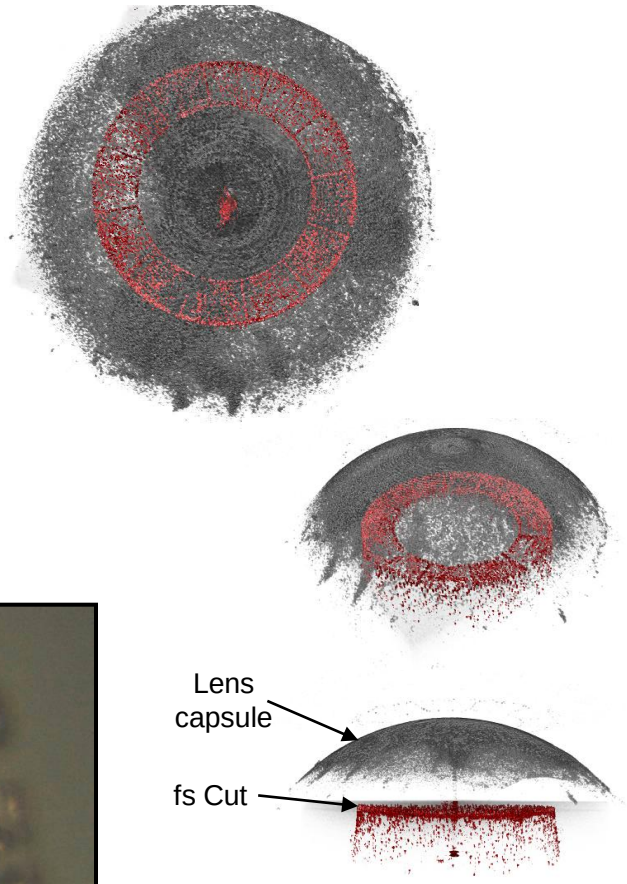
- Nuclear segmentation



OCT controlled fs Lentotomy (“lens softening”)







Prof. H. Lubatschowski, Rowiak

Outlook for Femtosecond Lasers in Ophthalmology for the next twenty years

- The **short pulse length** of femtosecond lasers enables **minimal pulse energies** which are the key to a **precise and gentle** laser surgery.
- 50 years after the invention of the laser, the **surgical laser knife** has finally become **true.**
- **Internal material modification** without even opening the eye is now possible and will enable many new applications.
- More inventions and innovations will be seen in the coming years

“We haven't even started yet”