réf. 217b

INDUSTRIAL FEMTOSECOND LASERS FOR ADVANCED MANUFACTURING APPLICATIONS

Clemens Hönninger

Amplitude SYSTEMES

OUTLINE

- Who are we?
- Industrial lasers & applications
- Trends
- Conclusions

Who are we?

- The largest ultrafast laser company in the world
- More than 300 employees in ultrafast lasers
- Extensive R&D and engineering teams
- Products sold worldwide since 2001

Amplitude Laser Group

Amplitude SYSTEMES

Amplitude SYSTEMES

Amplitude TECHNOLOGIES

Continuum®

OUTLINE

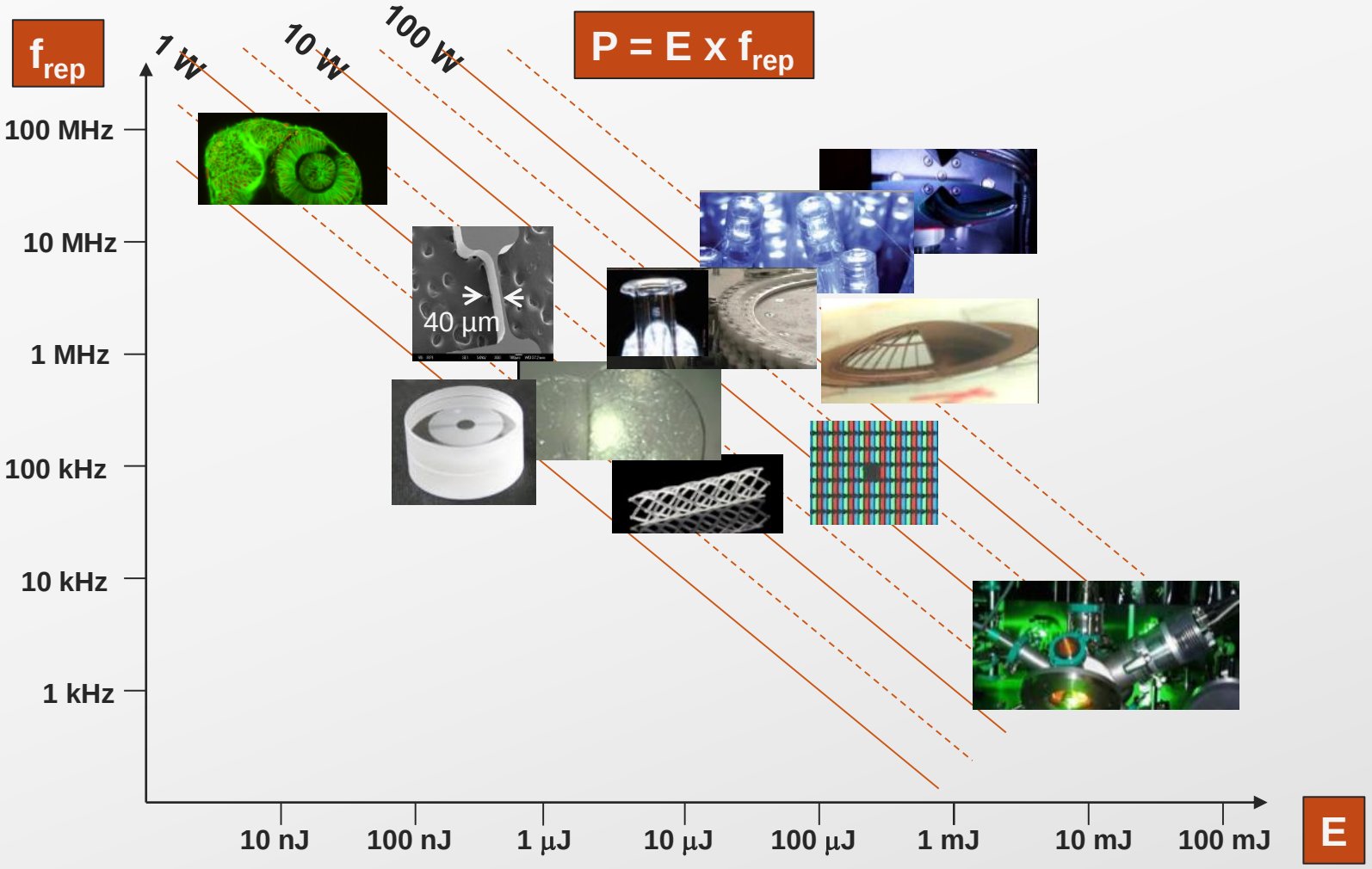
- Who are we?
- **Industrial lasers & applications**
- Trends
- Conclusions

Driving reliability and innovation

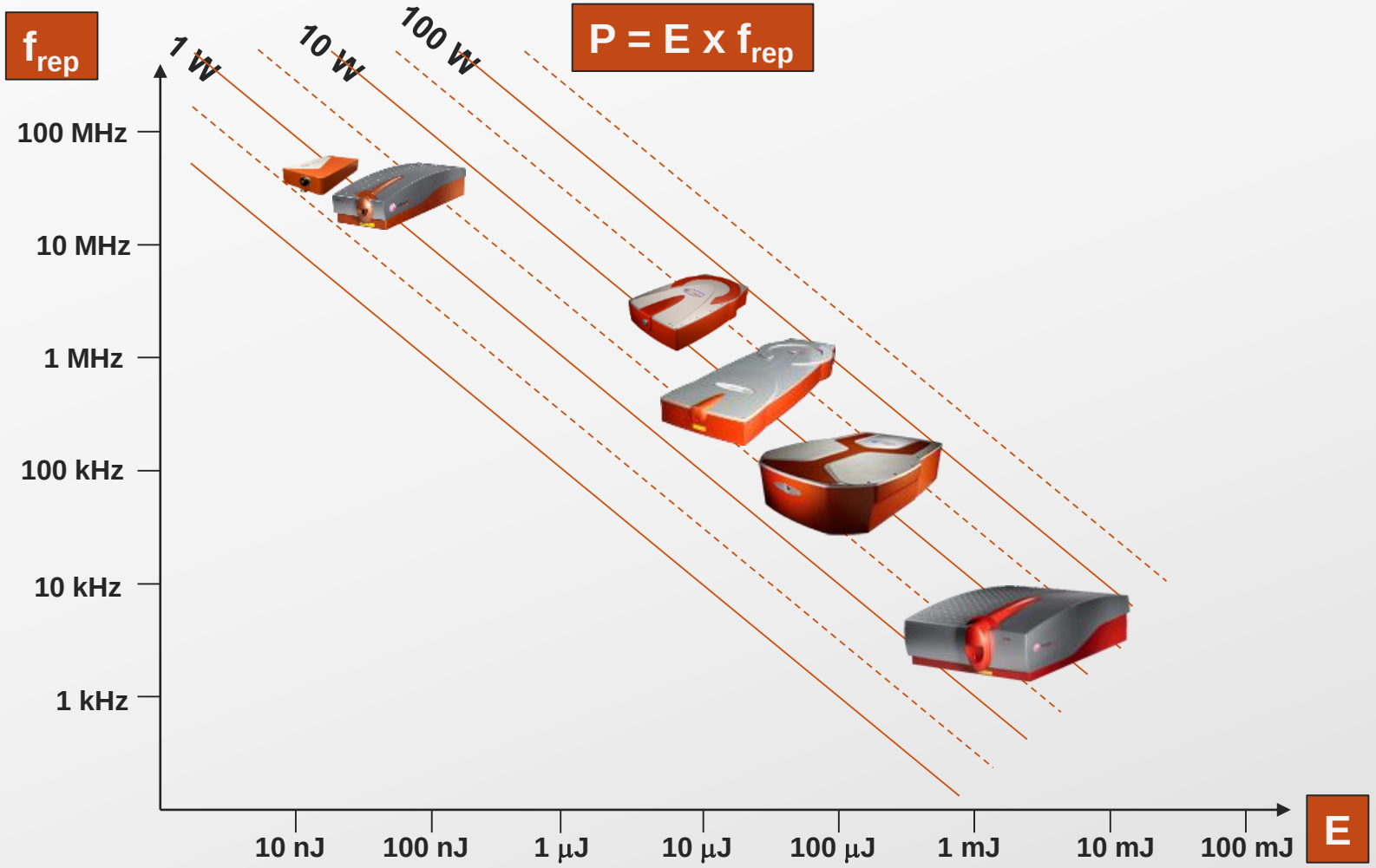
- **3000 m²** of clean room production, from mechanical assembly to quality control
- **ISO 9001** and **ISO 13485** certified

→ **Picosecond** and **femtosecond** lasers
→ High quality laser systems : **reliability**, **robustness**, **specification** and **compact** footprint

Applications & Performance



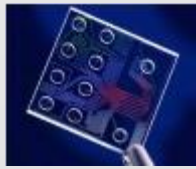
A wide range of specifications



Satsuma & Tangerine

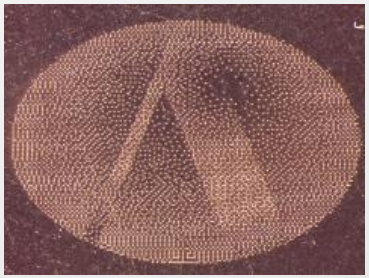
High repetition rate ultrafast fiber laser

	Satsuma	Tangerine
Pulse duration	< 400 fs (user-variable from < 400 fs to 10 ps)	
Average power	**> 50 W**	> 35 W
Pulse energy	> 40 µJ	**> 200 µJ**
Repetition rate	**Single shot to > 2 MHz, Burst mode, High speed sync.**	
Wavelength	1030 nm	
Beam quality	$M^2 < 1.3$	
SHG/THG	Optional	



System technology: High speed with Polygone scanner

- User access to Pulse picker
- Synchronisation between Laser and Scanner for high speed processing

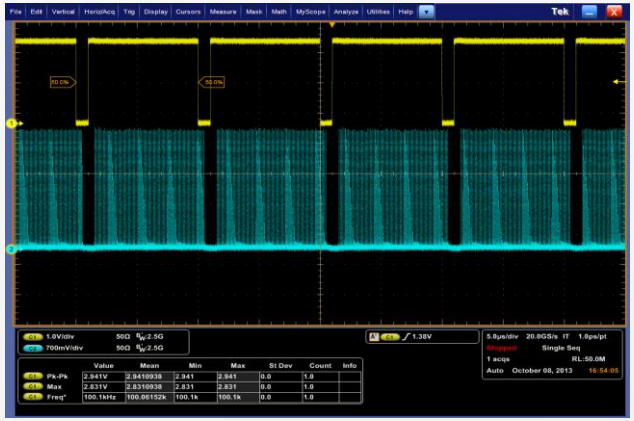


- **50 repetitive scans**
- High overlap between scans

B. Neuenschwander et al., Bern University of Applied Sciences, Engineering and Information Technology

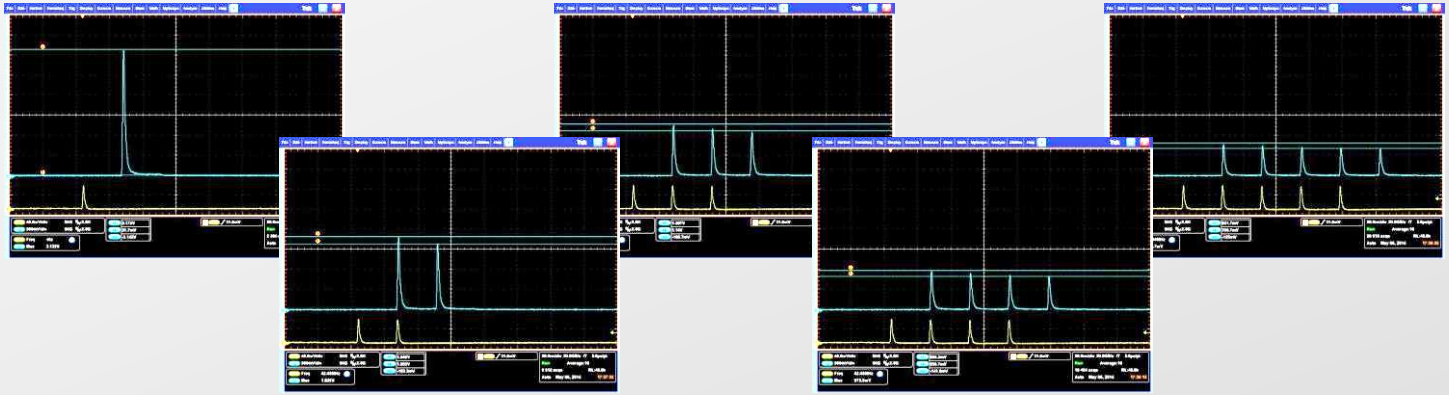
System technology: Fast Modulation and Burst Mode

- 10 MHz pulse train (duty cycle 90% shown, up to 99% realized):

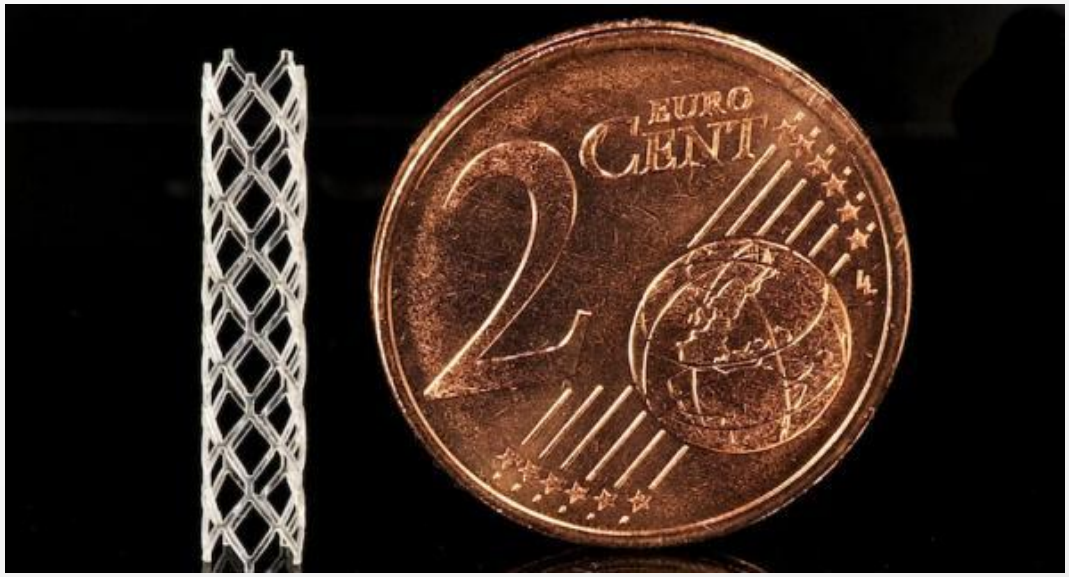


  - High Speed
  - Good Contrast

- Burst Mode:



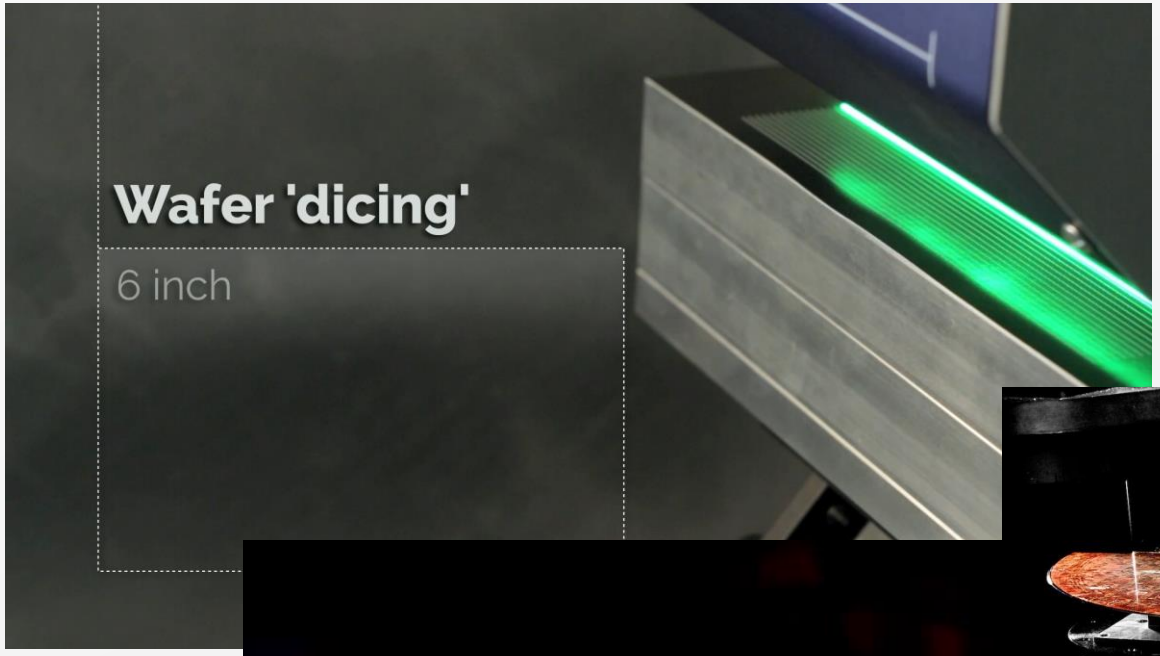
Medical device manufacturing



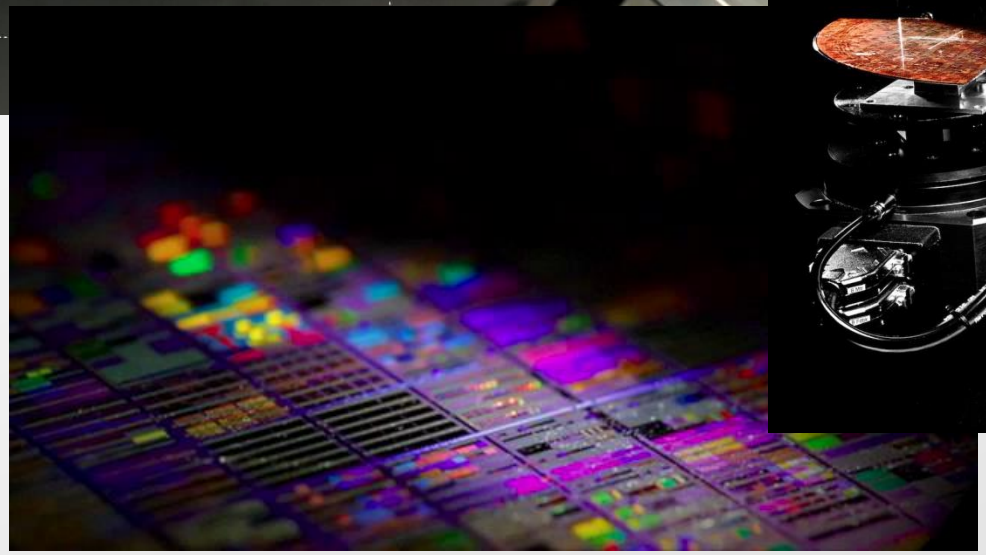
Bioresorbable stent

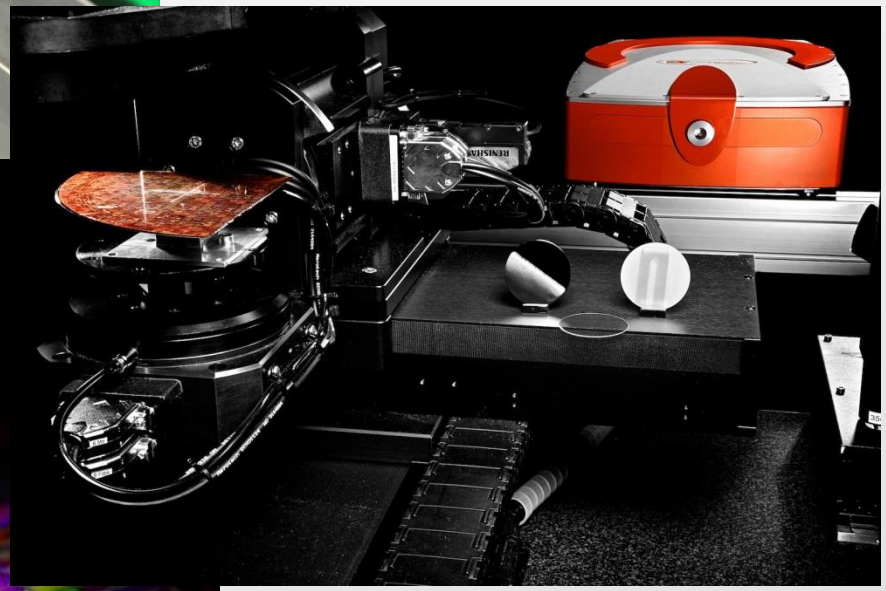
Intra-Ocular Lens

Semiconductor wafer scribing and dicing

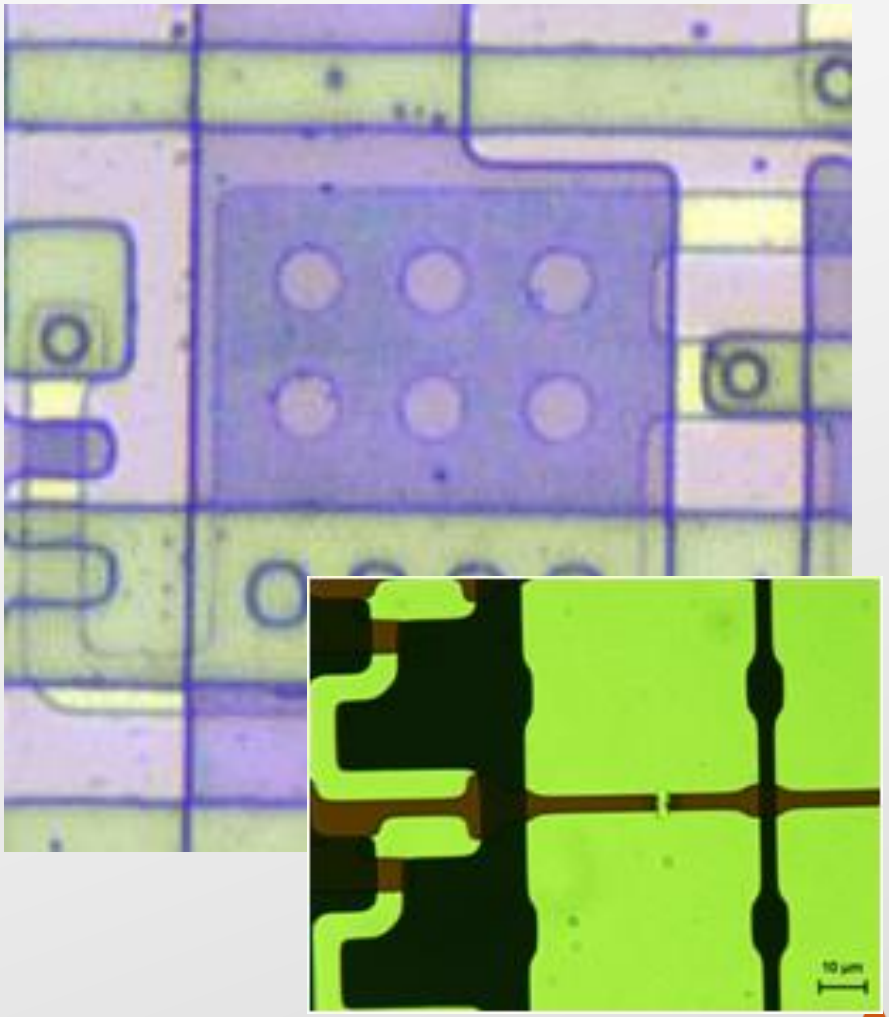


Credits: NextScan





Display industry



12-1310 UPMOST
Ultrafast laser Processing for MObile diSplay Technology

EURIPIDES

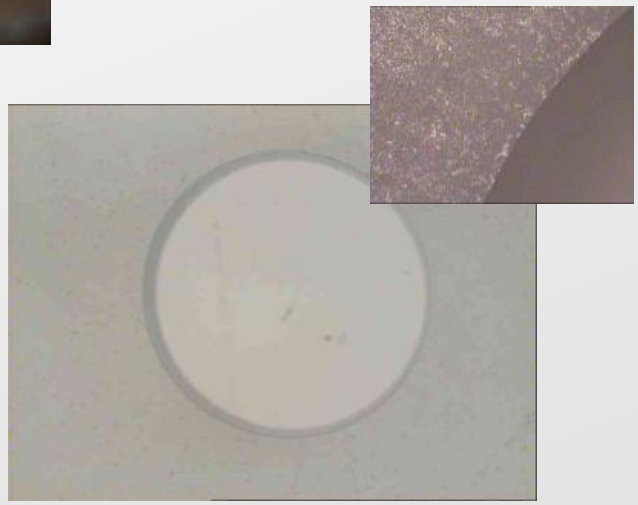
LABELLED

Start	03-Sep-2012
End	01-Sep-2015
Duration	36 months
Total cost	€ 2,57 Million

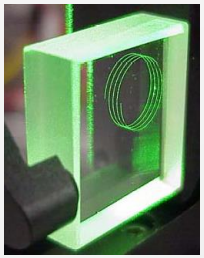
France: **43,5 %**
South Korea: **40,9 %**
Belgium: **15,6 %**

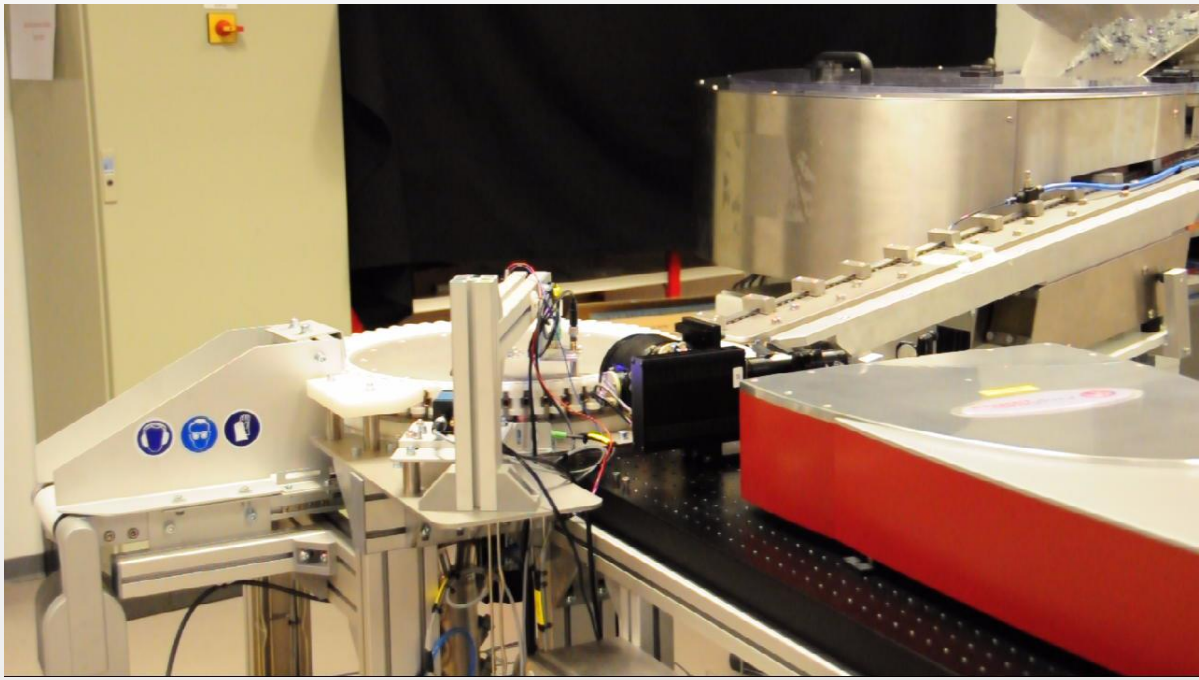
The project is devoted to the development of ultrafast laser processing for advanced mobile displays. The objective is to develop a non-thermal, ultra precision machining process utilizing femtosecond lasers and novel optical systems for beam shaping and pulse shaping. It is to provide a fully customized fabrication means for high resolution mobile displays as submicron precision is required as the pixel size of such HD displays decreases.2,57

Transparent material cutting or marking

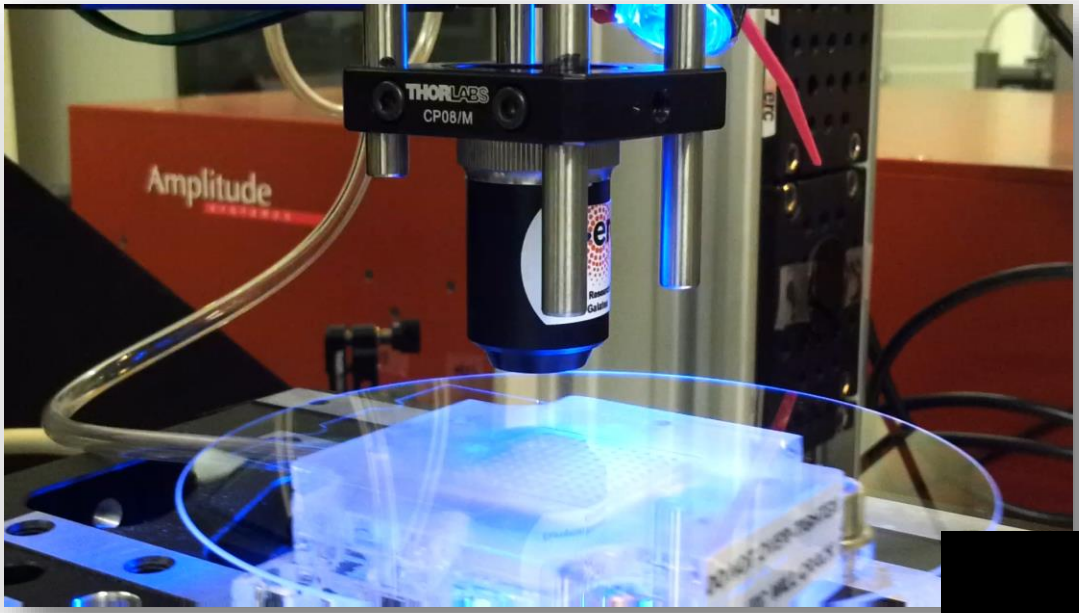


Internal marking

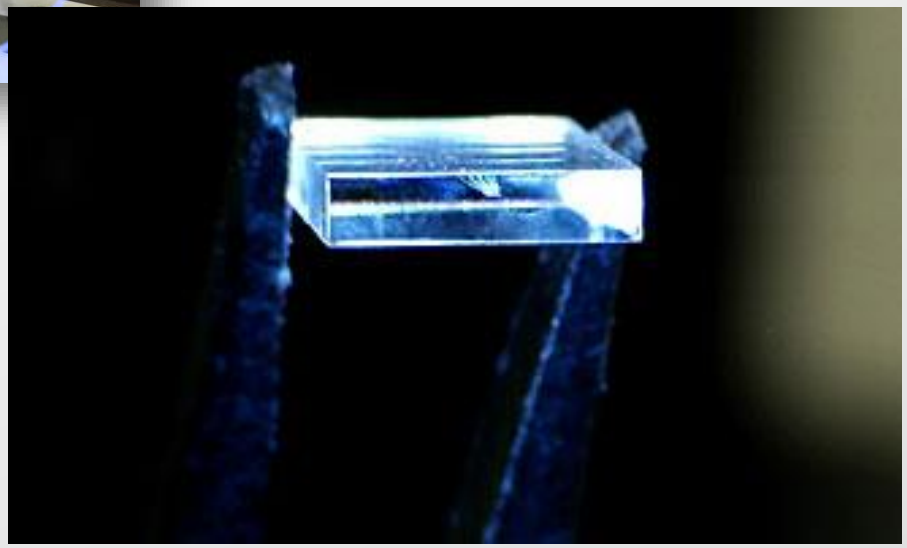




Lab-on-chip and waveguide

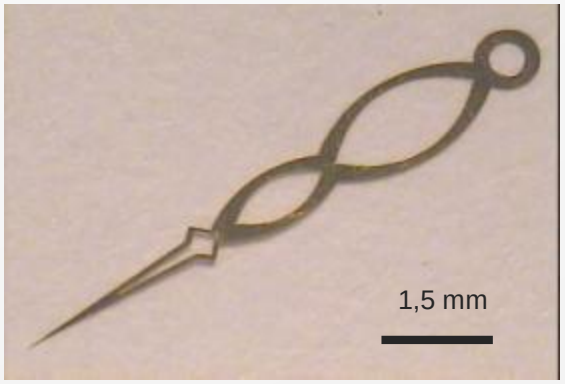


Femtoprint SA
micro- and nano-devices out of glass

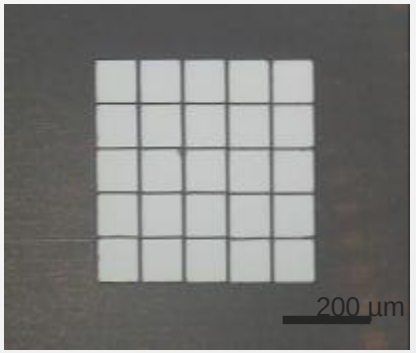


Metal engraving and cutting

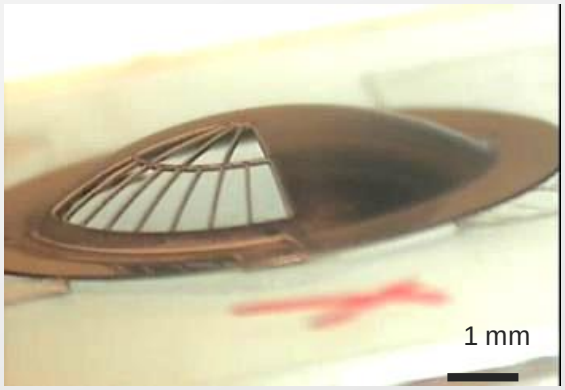
Pioneer in watch industry ultrafast process



Gold - thickness.25µm



Platinum - thickness.10µm Bars width 10µm



Metal - thickness.50µm Bars width 90µm

Metal and via drilling

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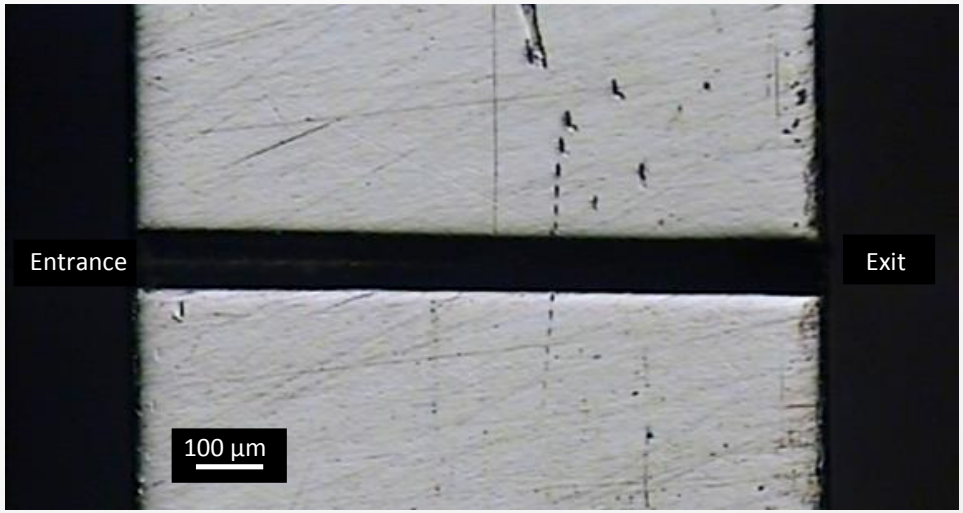
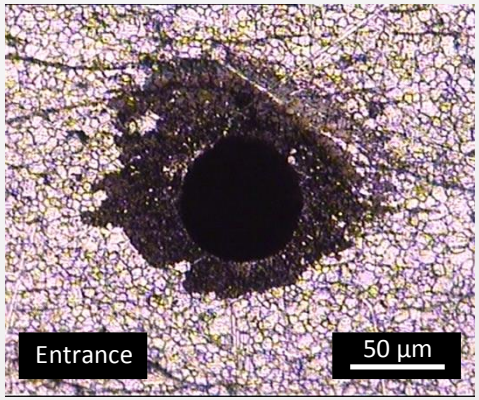
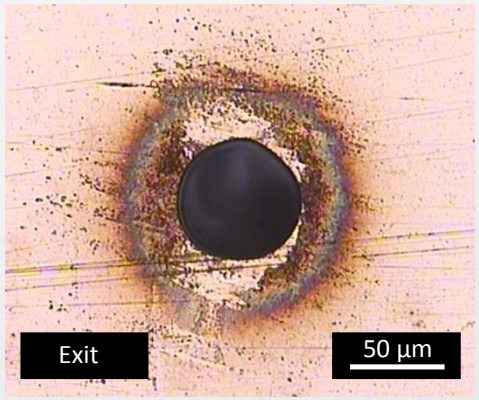
Stainless steel 900µm-thick



- Entrance diameter 65 ±3µm
- Exit diameter 65 ±1µm
- Circularity defect ±2µm
- **Conicity 0.0° ±0.1°**
- Aspect ratio 14:1



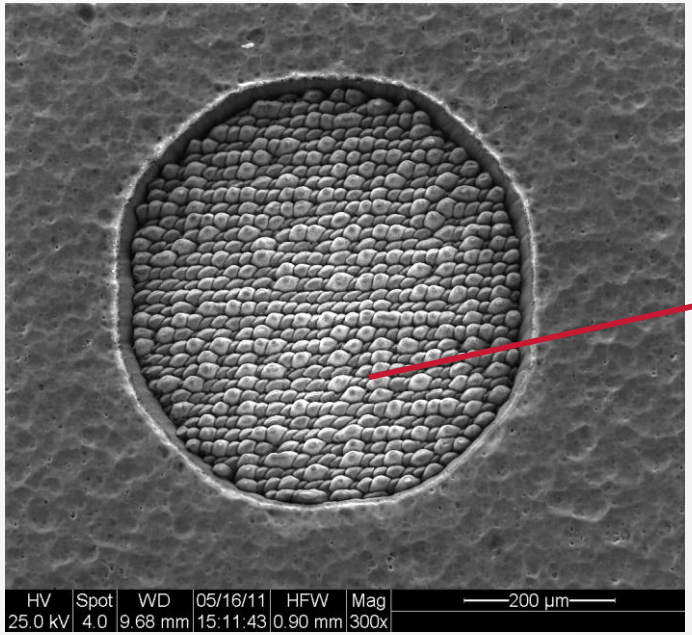


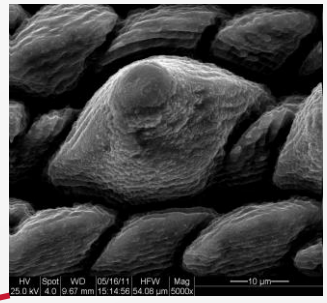
Op. parameters : 1030nm 350fs 64µJ 100kHz no defocus

Automotive Industry

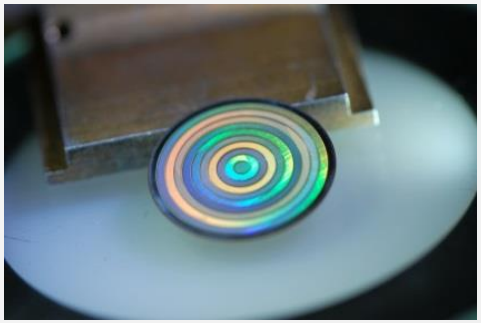
Credits: Alphanov - Celia

Texturing

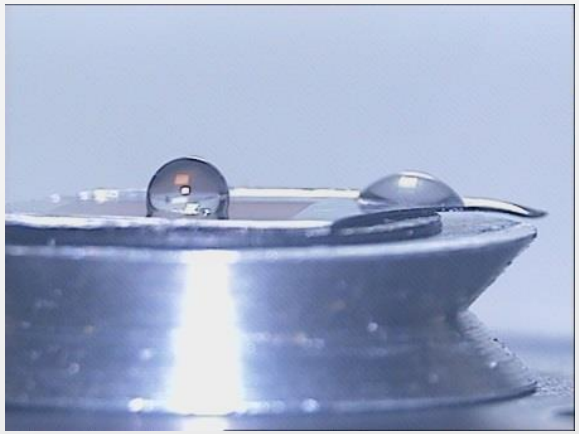




Credits: Lumyn Technologies



Credits: Alphanov



Black metal

OUTLINE

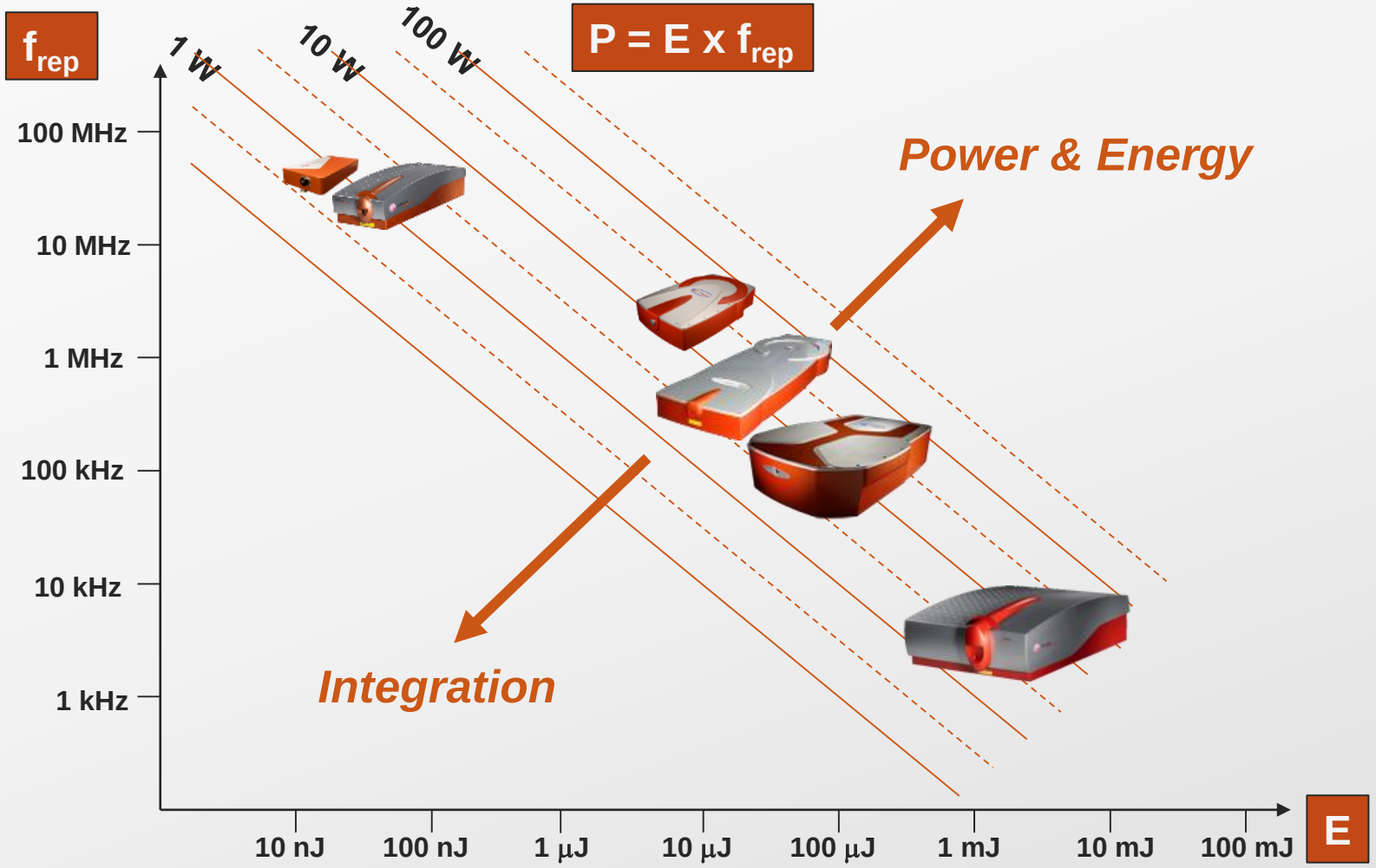
Who are we?

Industrial lasers & applications

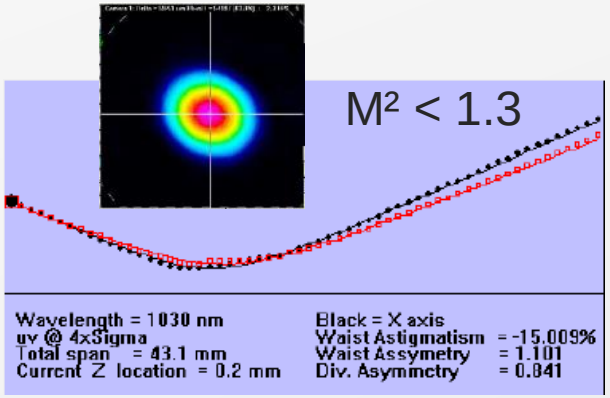
Trends

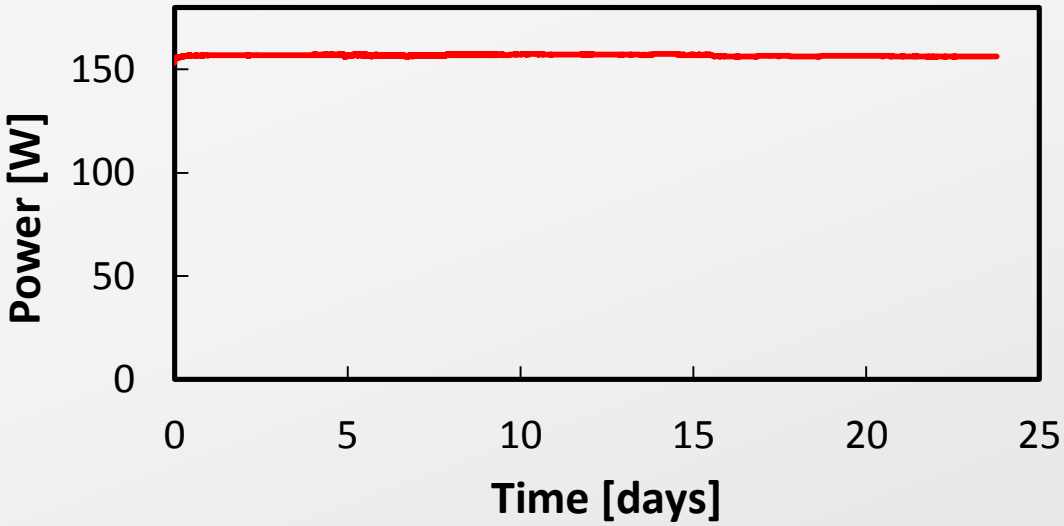
Conclusions

Trends

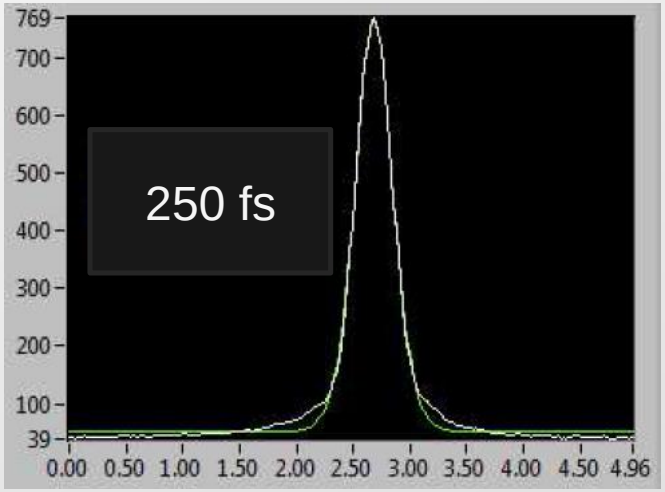


Power scaling of Satsuma platform





120 W after compression:



- **Energy limit because of mode confinement**

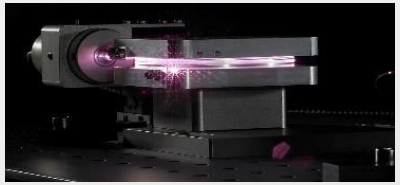
Power AND Energy scaling with Hybrid Fiber and Solid-State Architectures

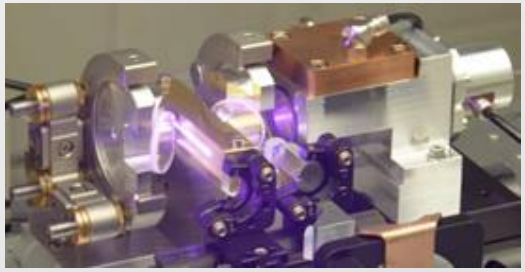
Amplitude SYSTEMES

Fiber-based Seeder → Crystal-based Booster →

- Compact and stable
- Short femtosecond pulses
- Flexibility
  - High/Low Reprates
  - Burst mode
  - Synchronisation

- Higher gain / length
- Reduced non-linearities
- high energy capability
  - Peak powers > 10 MW without CPA
  - **4.4 GW with CPA (2.3 mJ, 520 fs)**
- High Speed (>>MHz) and burst mode





High power femtosecond laser with Hybrid Fiber and Solid-State Architecture

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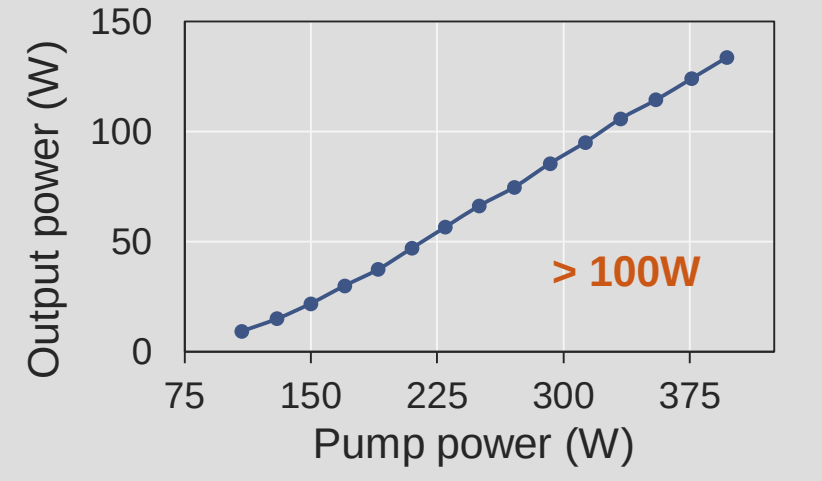
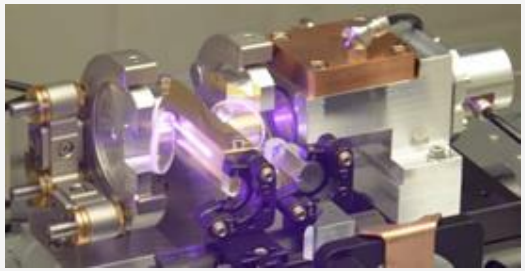
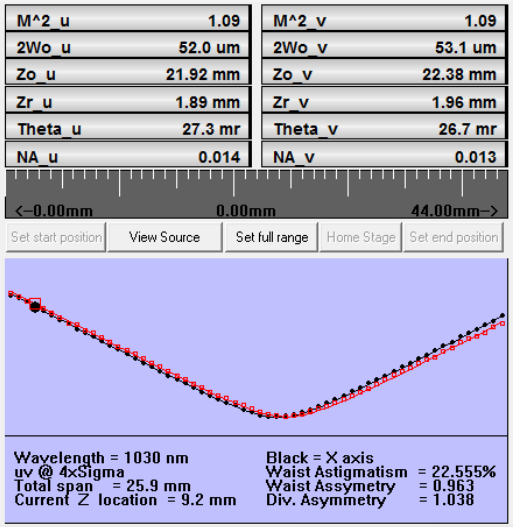
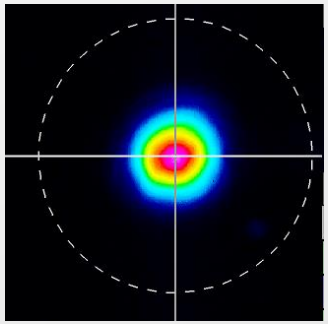
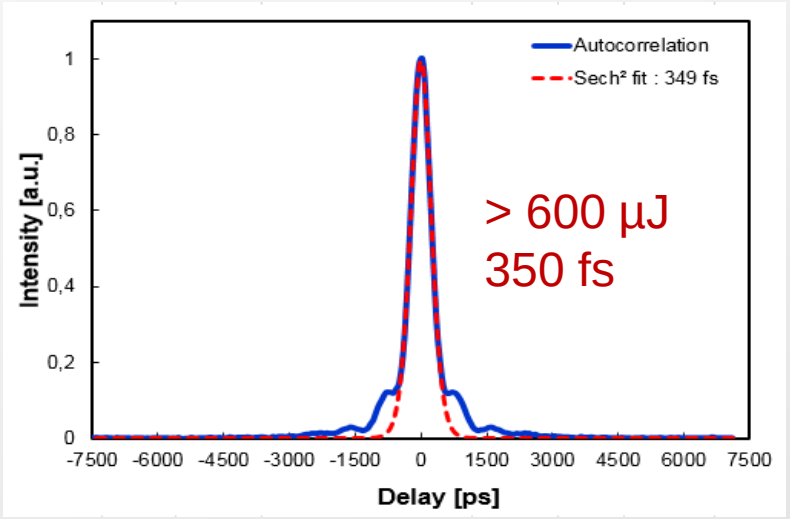




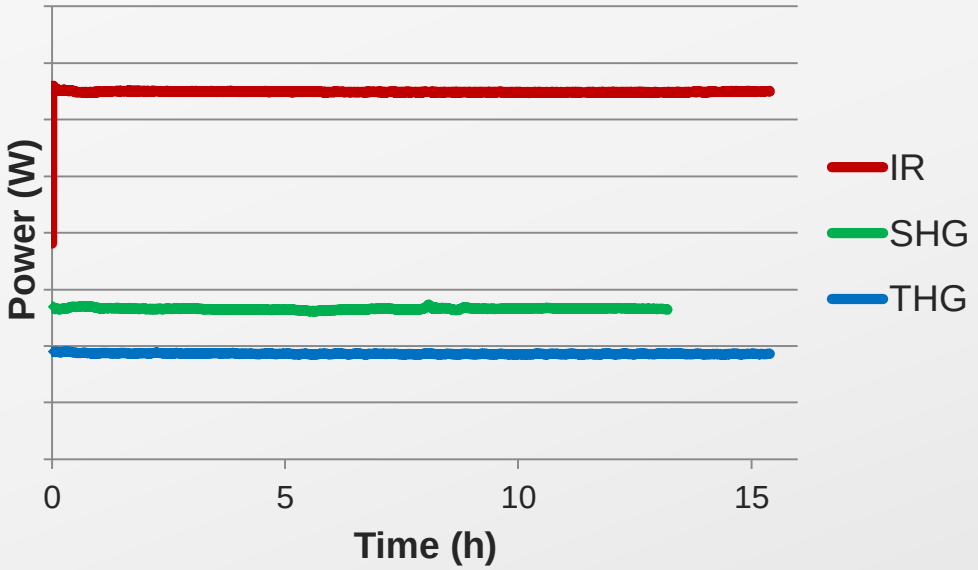






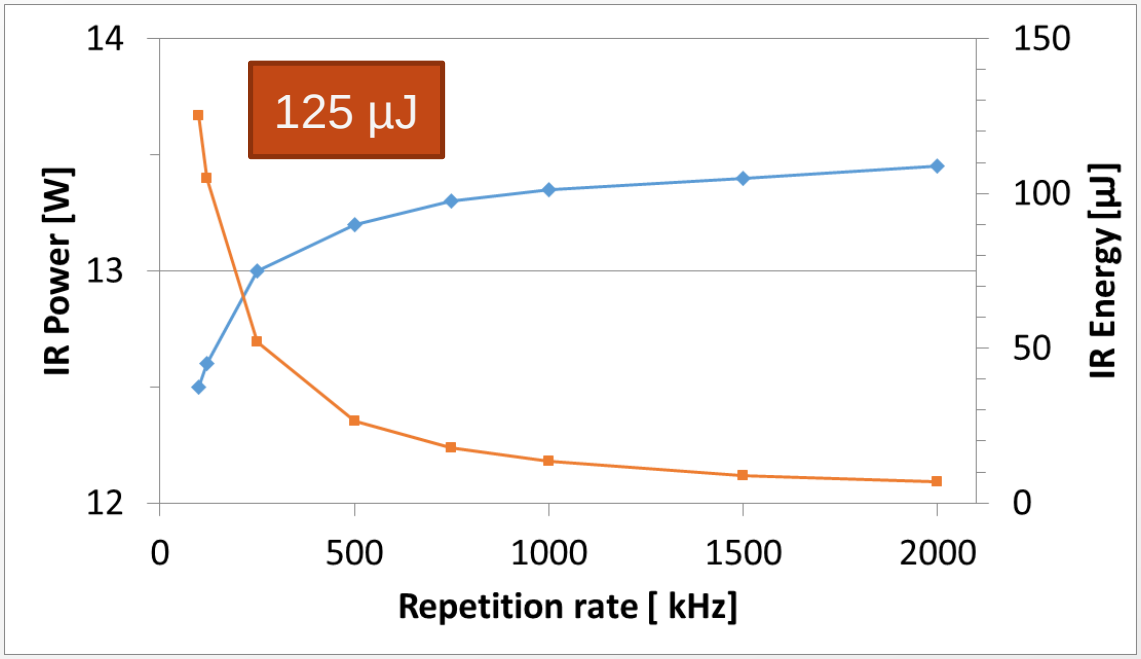
- High frequency conversion efficiencies
  - > 50% in SHG, up to 30% in UV

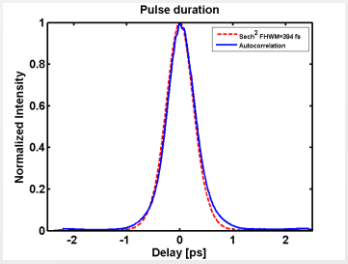
Hybrid: compact & integrated



- Compact: 35 x 23 x 17 cm3
- Modular for
  - high stability
  - flexibility (e.g. frequency conversion options)

Compact & performing





- 450+/-25 fs over the full parameter range

Amplitude SYSTEMES

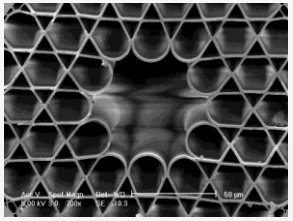
Feed rates 100mm/s demonstrated

Fiber transport – femto power & compression

Amplitude SYSTEMES

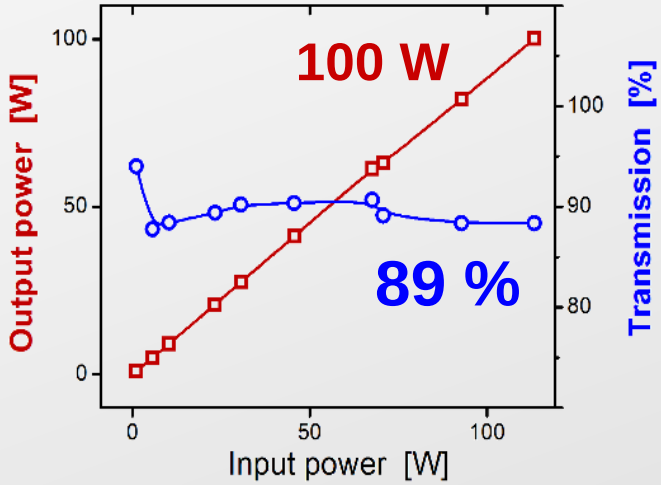
GPPMM Gas-Phase Photonic & Microwave Materials

GLOphotonics The Photonic Microcell Company™

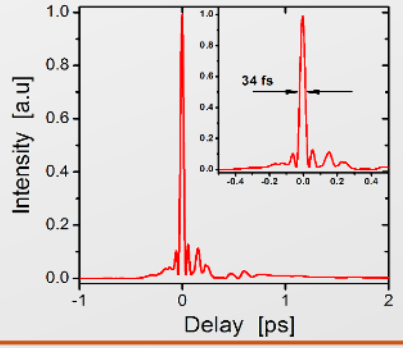


photonic tools

- Pulse energy: up to 1mJ
- Excellent power transmission



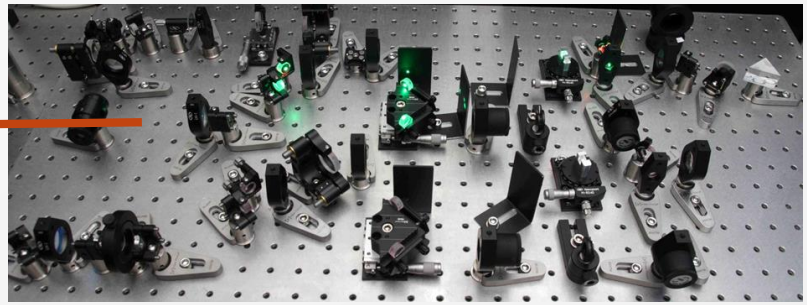
- Pulse compression (factor ~10)
  350 fs => 34 fs



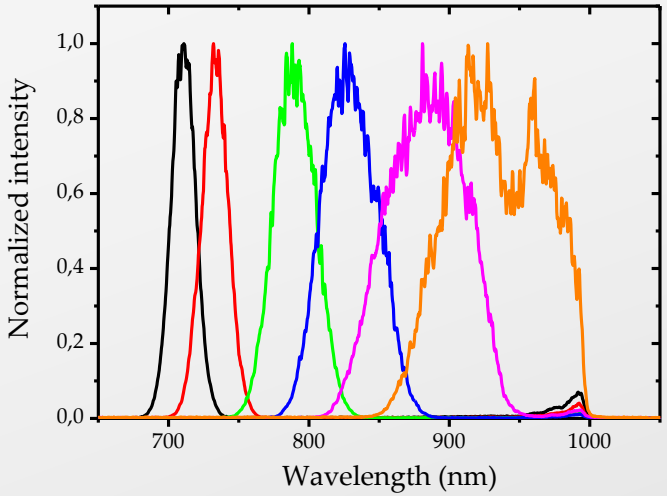
Wavelength tunability & Short Pulses

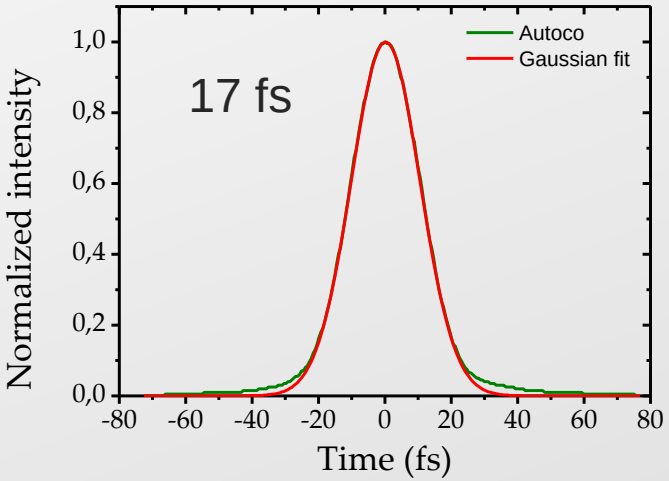
J. Nillon et al., Opt. Ex. (2014)

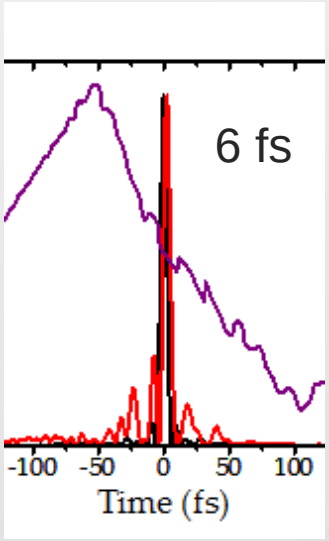
100µJ, 400 fs



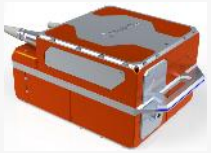
- 600 to 1000 nm
- > 10 µJ @ ~800 nm
- << 100 fs







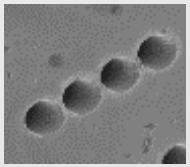
Conclusion & Outlook



Femtosecond lasers are

- High energy, > mJ
- High power, > 100W
- compact & integrated
- flexible
  - Burst mode
  - High speed sync

- Fiber transport
- 100-fs and shorter pulses
- New wavelengths (OPA)





Amplitude
SYSTEMES
Nothing but ultrafast.

Thank you for your attention