



TruMicro Serie 2000



TruMicro Serie 6000



TruMicro Serie 9000

3.4 Ultra Short Pulse Laser

Dr. Claus Schnitzler, AMPHOS GmbH

Ultrashort Pulses

The Evolution in Precision – „in Time“

Pulses with Duration in the picosecond and femtosecond regime

1ps pulse duration is a slice of light with 0.3mm length

1MHz replate translates in a distance between those pulses of 300m

Basically the laser is „OFF“ all the time, but when it is „ON“ the Power is huge

Focussed down to 10um or less, no material can take this

$$P_{peak} = \frac{E_{pulse}}{\tau_{pulse}}$$



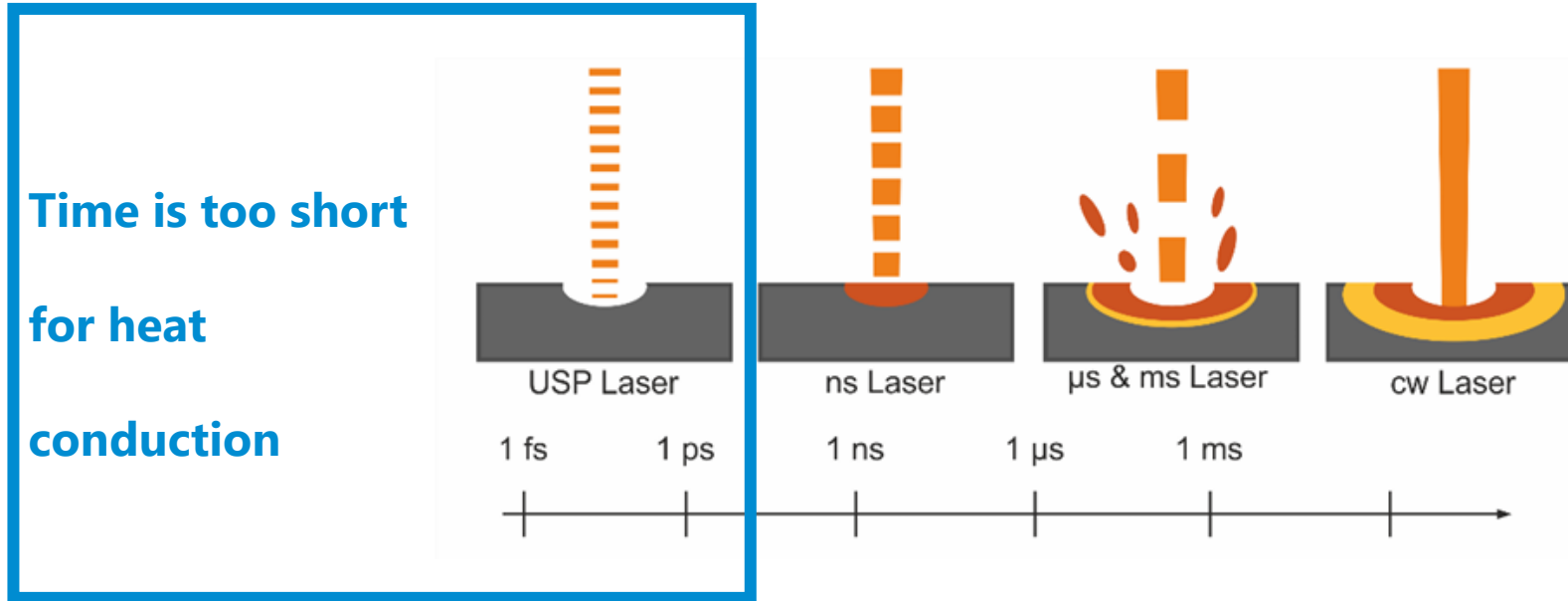
100μJ, 1ps

100 MW

Ultrashort Pulses allow Ablation of any Material

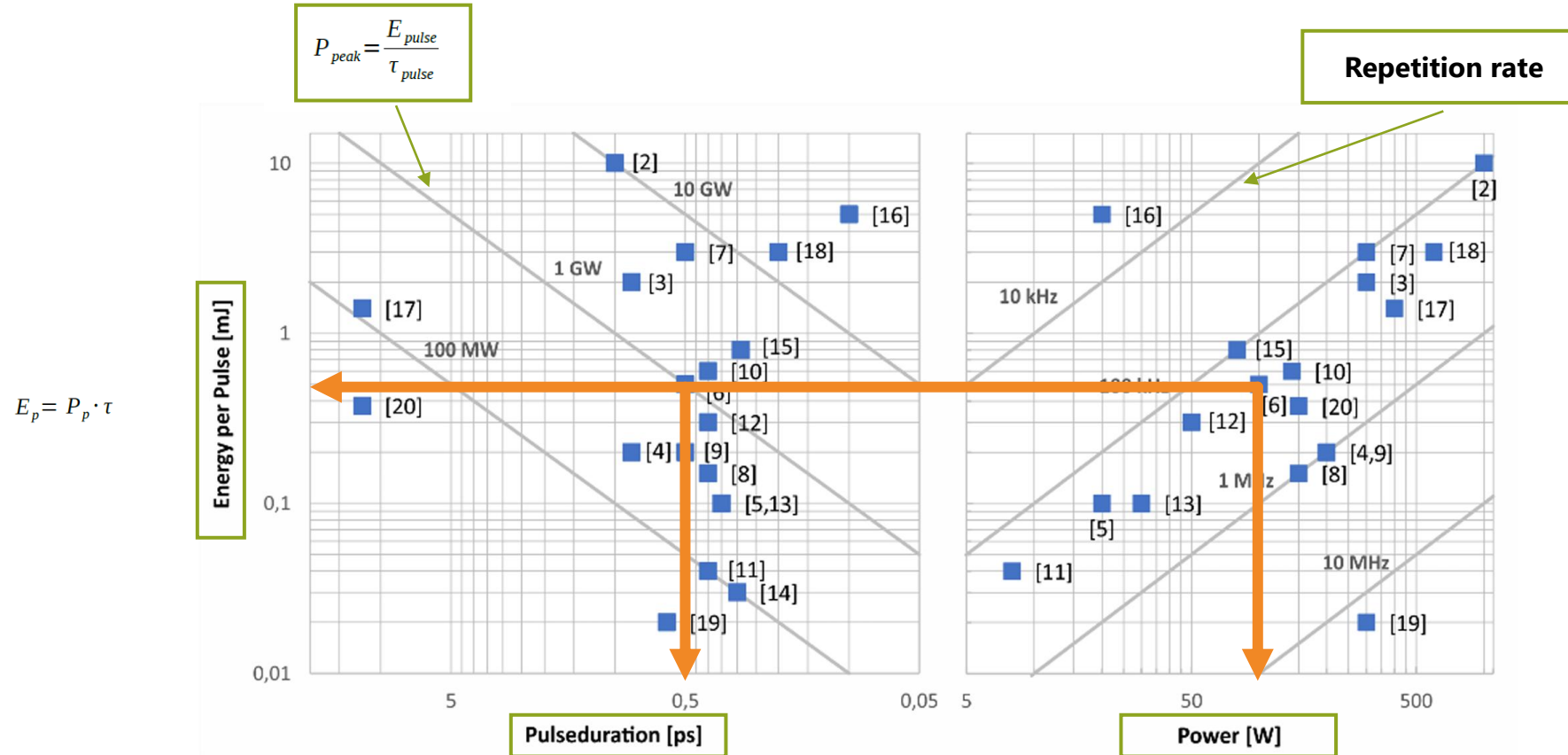
Ultrashort Pulses do not generate Heat

... if applied in a correct way



5 Characteristic Parameters in One Diagram

Picking the right Laser

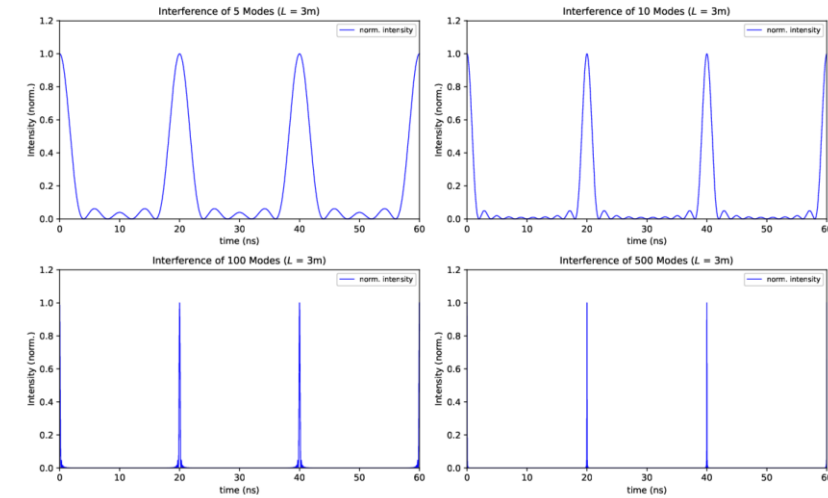
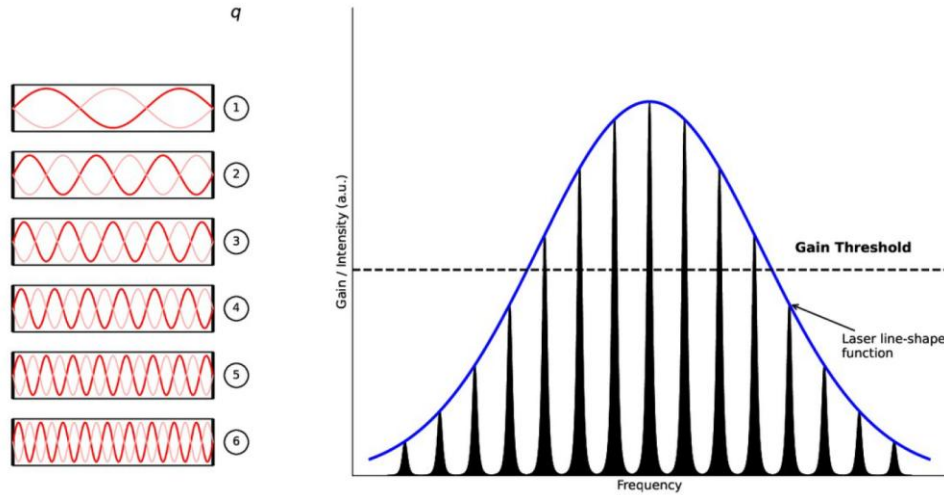


100 W
500 μJ
1 ps
200 kHz
500 MW

Overlay the application map and you find the right laser!

Modelocking

There is no switch* to generate a femtosecond pulse – only interference can do it



$L = 3 \text{ m}$
 $\lambda_m = 1030 \text{ nm}$
 $q = 6.000.000$
 $d\lambda_m = 0.177 \text{ pm}$

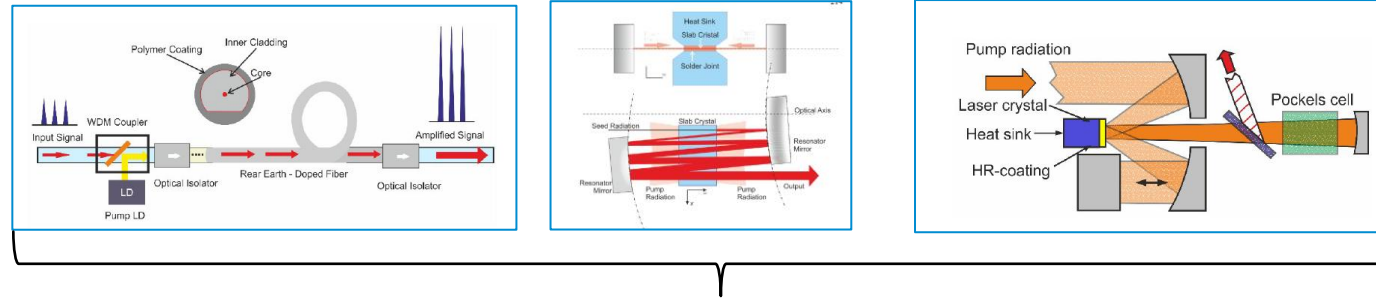
Peak intensity is proportional to N^2
 Pulse duration proportional to $1/N$

Modelocked Oscillator defines a raster in time with precise spacing (e.g. 20ns at 50MHz)

*at least not now...

Master-Oscillator-Power-Amplifier MOPA

Combining different technologies to get to the right power level (GHz to mJ)



Oscillator



Pulspicker



Amplifier



Modulator

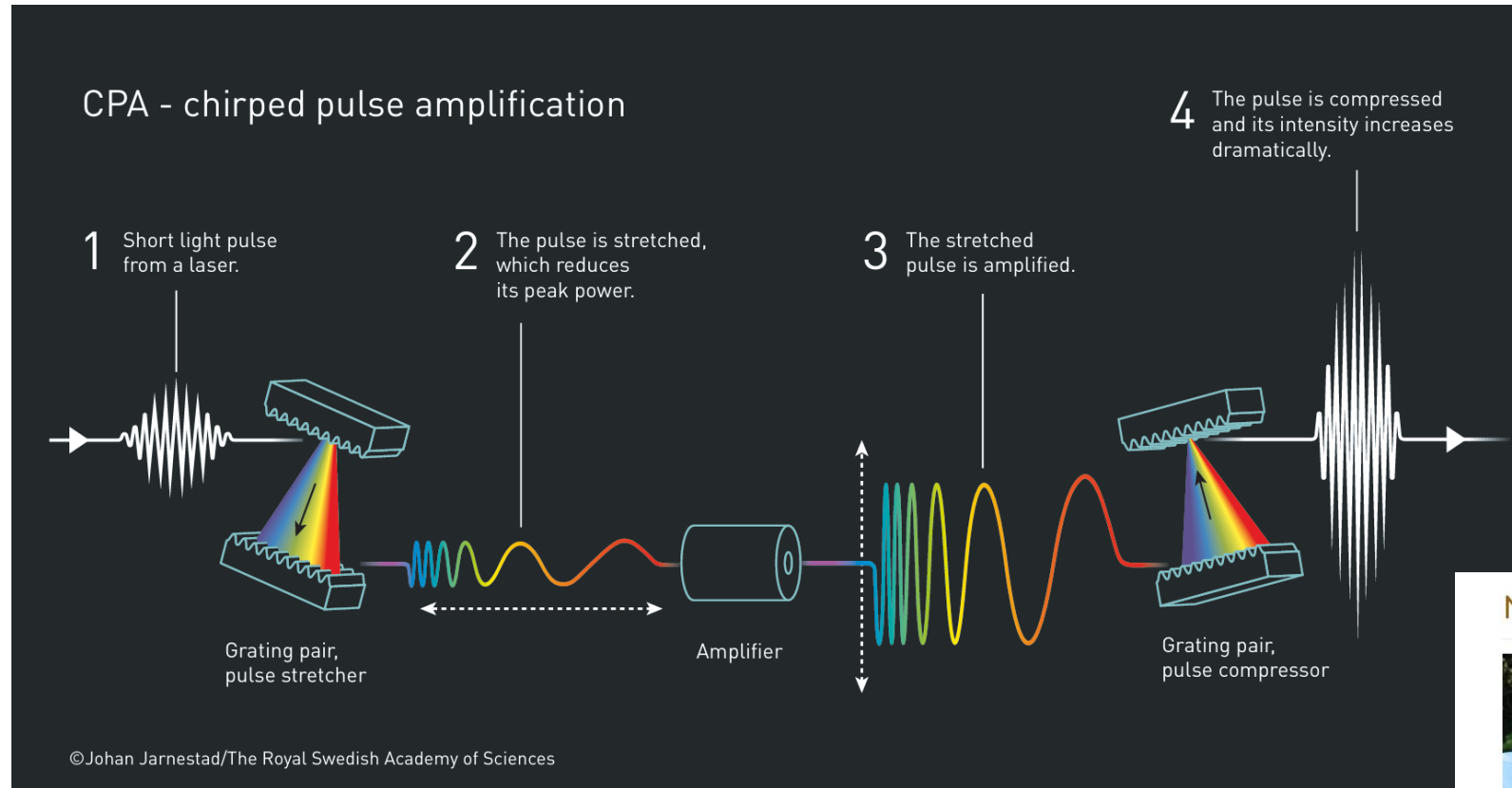


NLO

CPA (Chirped Pulse Amplification) is a known technique to build high energy lasers

Deep Dive: Chirped Pulse Amplification

Stretch – Amplify – Compress



Nobel Prize in Physics 2018



© Arthur Ashkin
Arthur Ashkin
Prize share: 1/2



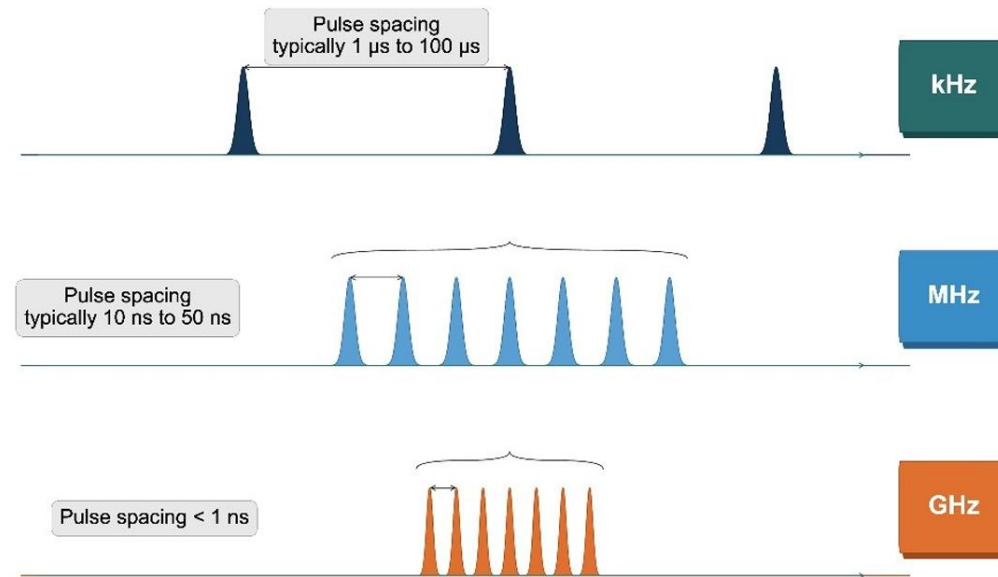
© Nobel Prize Outreach, Photos: A. Mahmoud
Gérard Mourou
Prize share: 1/4



© Nobel Prize Outreach, Photos: A. Mahmoud
Donna Strickland
Prize share: 1/4

Pulse Bursts: Distribution of Energy in Time

Ongoing Development to expand the parameter space

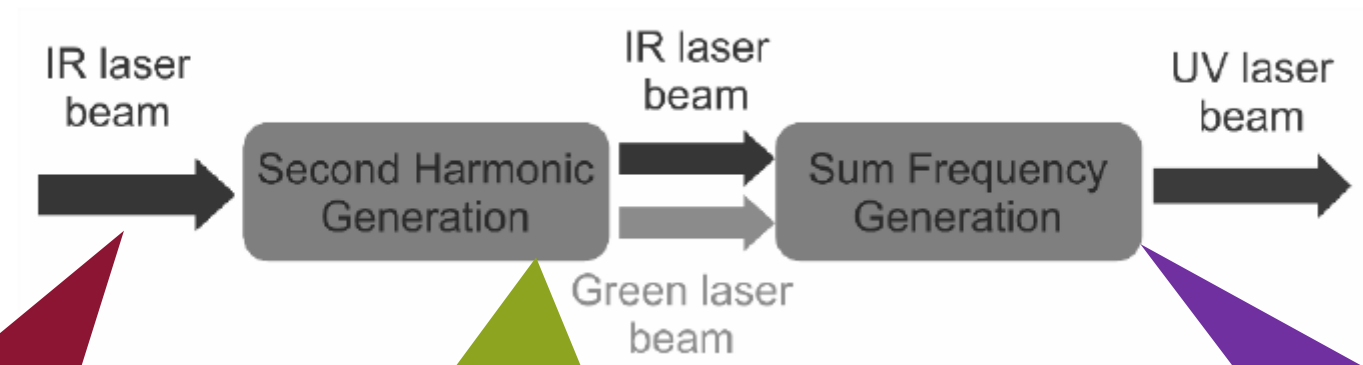


Distribution of Energy in Time can improve processes dramatically (Efficiency, Quality,...)

Nice Feature: Shorter Wavelengths

Harmonics of Fundamental Wavelength can be generated due to high peak power

Typ. Wavelength schemes: 1030 – 515 – 343 – 257.5



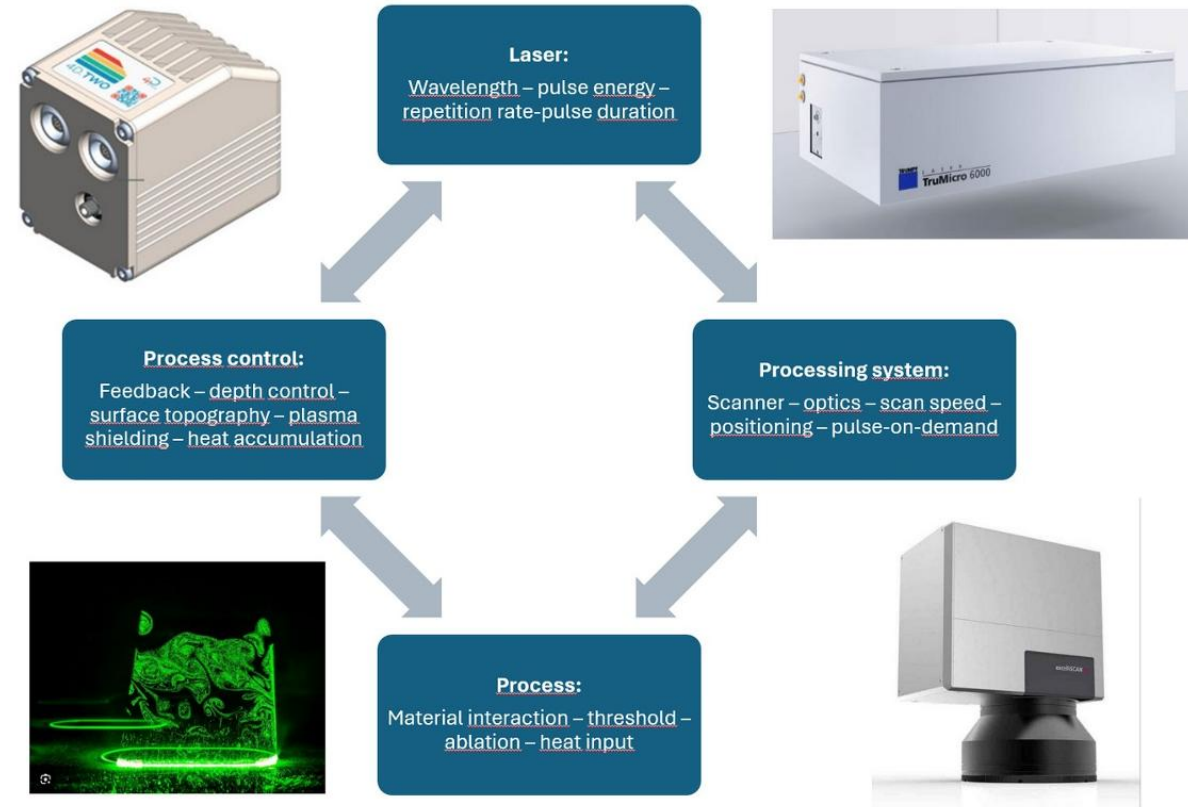
High Peak Power IR beam

**Nonlinear effects
due to high intensity
Typ. 50% efficiency**

**Nonlinear effects
due to high intensity**

Get the Best out of Ultrashort Pulses

Only when considering the whole system!



Summary

Ultrafast Lasers allow the Cold Ablation of any Material with highest Precision

Ultrafast Lasers are unique tools for **cold ablation of any material**

- Pulse duration in the range of 1ps is the key for highest peak power
- Low Energy (μJ) results in precise ablation

Modelocking is the fundamental technique to generate pulses.

Several amplification technologies are available depending on the parameters: **Fiber, Slab, Disk**

Further splitting of the energy to bursts (MHz, GHz) allows for better processes

„**Teamwork**“ of Lasersource, Scanner, Process, Control is key for optimizing applications

What's Next: higher power, higher energy, shorter pulses,...



Claus Schnitzler

Management

+49 241 565292 -10

info@amphos.de



Member of the TRUMPF Group



www.amphos.de