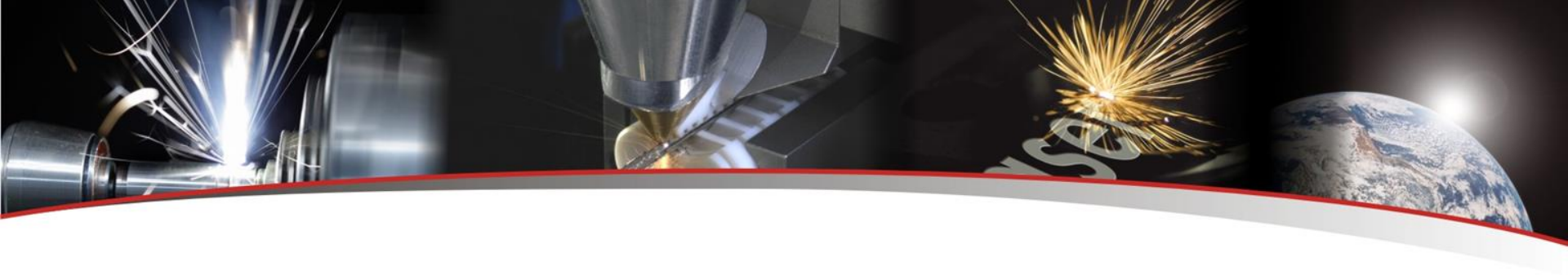


rofin

Architecture of Industrial USP Lasers

Ultrafast Laser Processing Forum 2015

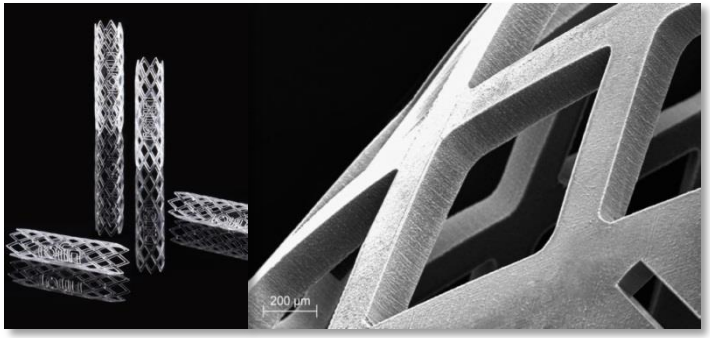
Dr. Georg Ernst

Content

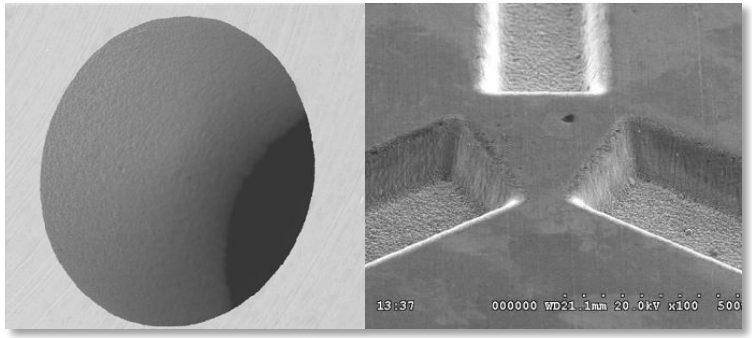
- **Material processing applications**
- Laser Source Requirements
- Industrial USP Laser Solution

Ultrashort Pulse Laser Applications

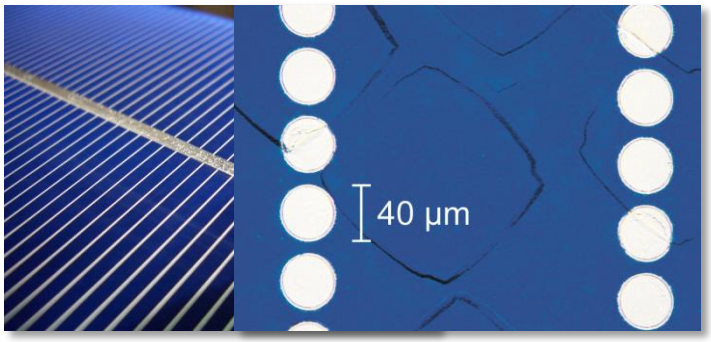
- „Cold“ Material Processing
- Processing Metals, Polymers, Ceramics…
- Minimized Postprocessing



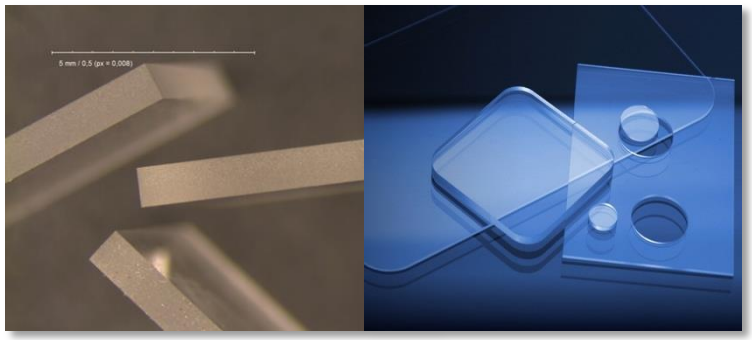
Micro Cutting



Drilling, Micro Structuring



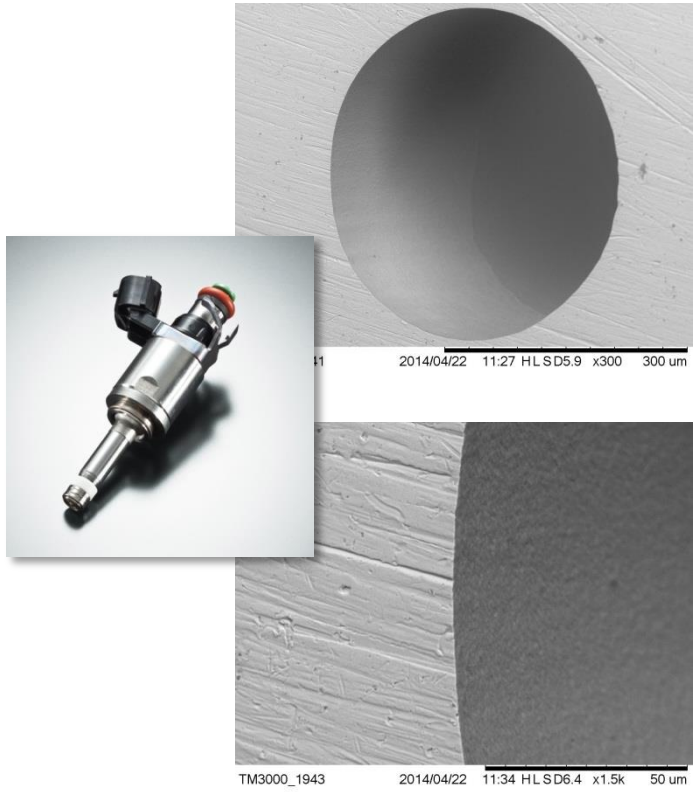
Ablation of Thin Layers



SmartCleave™ FI

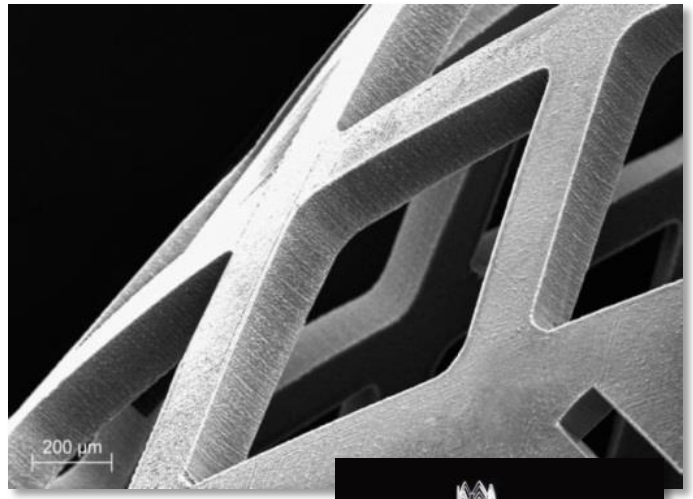
Injector Nozzle Drilling (GDI)

- More possibilities in hole design
- Industrially proven process
- Unsurpassed hole quality
- Pulse duration ideally <1ps
- Pulse energy limited to <100µJ
- Drilling at ~2sec. per hole, ~150µm∅



Tube Cutting – Medical Device

- Cutting of medical polymers
- Reduction in post processing steps
- < 1ps to reduce heat input
- <100µJ for full cut
- Requires:
  - High precision motion system
  - High end cutting optics



Engraving

- Tools and engineering components
- High end printing plates
- High end consumer products
- < 1ps to 15ps
- < 50µJ but high rep. rates

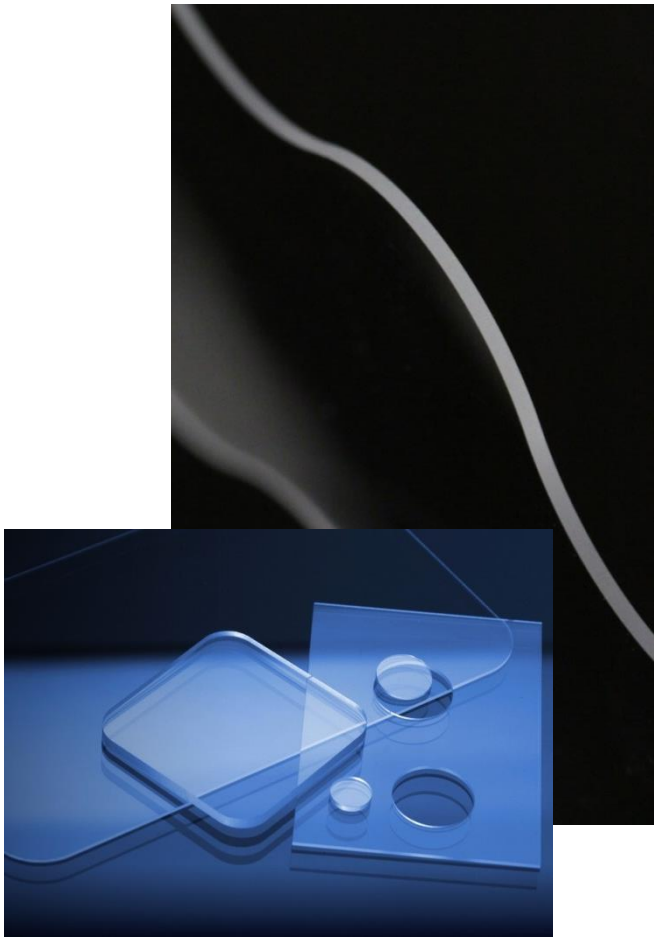
SmartCleave™FI Glass Cutting

rofin LASER MICRO

- Free form cutting at high speeds
- Cut > 2mm in single pass
- Pulse duration 1ps to 15ps
- Pulse energy > 100µJ
- Wide range of transparent and brittle materials

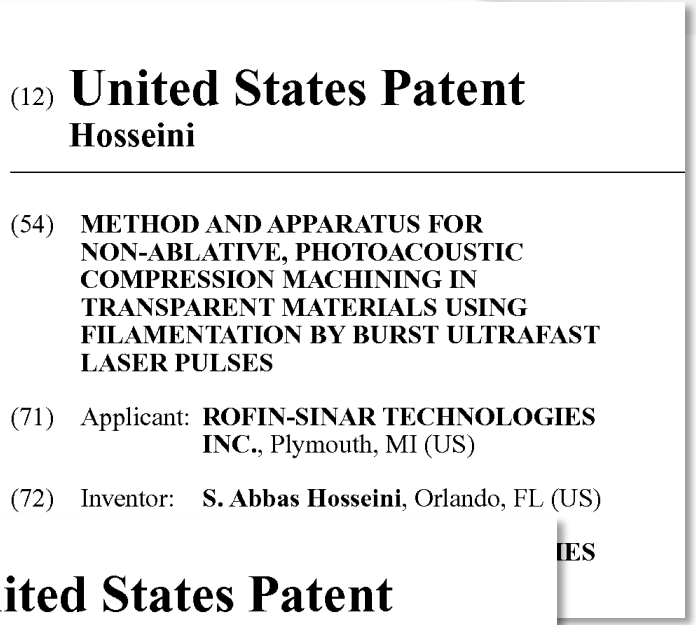
  (Sodalime, Borosilicate, Sapphire,

  Alkali-Alumino Silicate, $LiNbO_3$, …)



SmartCleave™FI Patented Process

- Several patents around hardware and process
- Long filaments due to special optics and burst
- Protect our customer`s investment
- Avoid additional costs

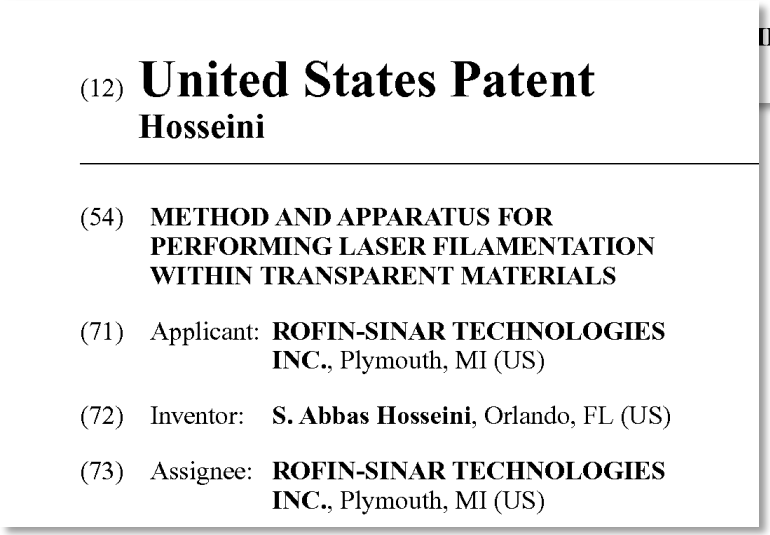


(12) **United States Patent**
Hosseini

(54) **METHOD AND APPARATUS FOR NON-ABLATIVE, PHOTOACOUSTIC COMPRESSION MACHINING IN TRANSPARENT MATERIALS USING FILAMENTATION BY BURST ULTRAFAST LASER PULSES**

(71) Applicant: **ROFIN-SINAR TECHNOLOGIES INC.**, Plymouth, MI (US)

(72) Inventor: **S. Abbas Hosseini**, Orlando, FL (US)



(12) **United States Patent**
Hosseini

(54) **METHOD AND APPARATUS FOR PERFORMING LASER FILAMENTATION WITHIN TRANSPARENT MATERIALS**

(71) Applicant: **ROFIN-SINAR TECHNOLOGIES INC.**, Plymouth, MI (US)

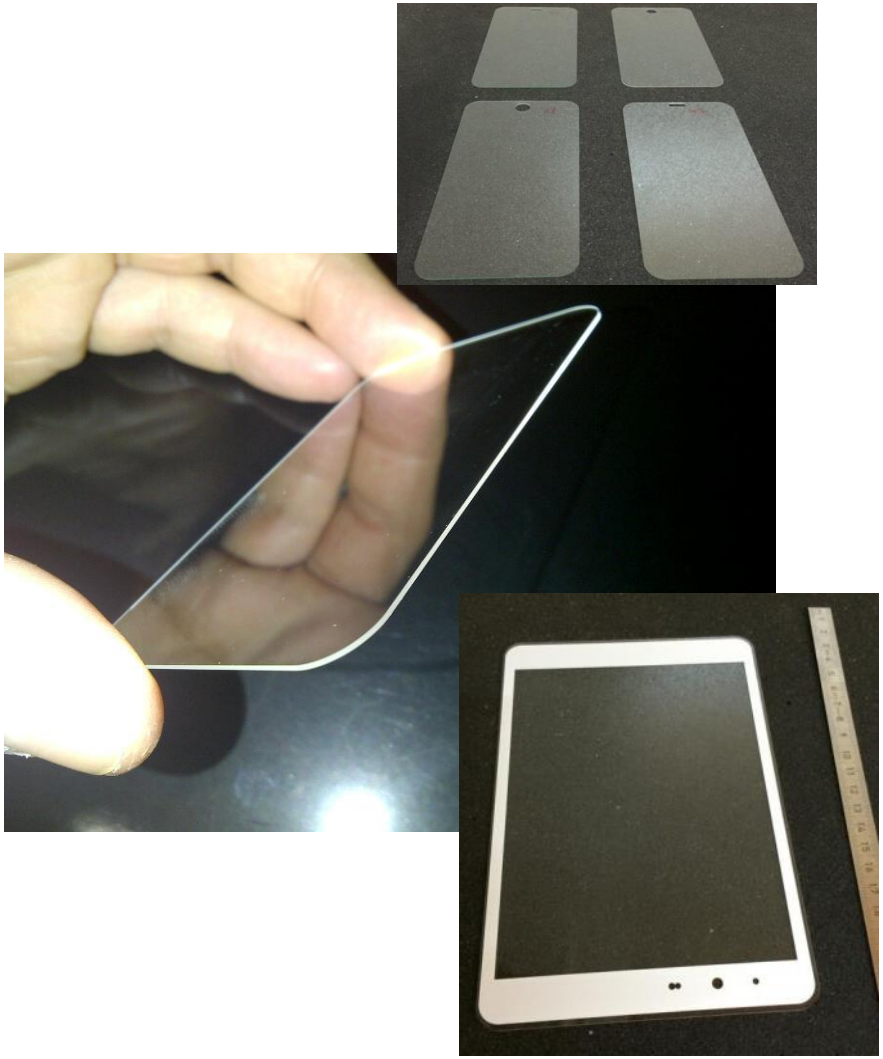
(72) Inventor: **S. Abbas Hosseini**, Orlando, FL (US)

(73) Assignee: **ROFIN-SINAR TECHNOLOGIES INC.**, Plymouth, MI (US)

SmartCleave™FI technology

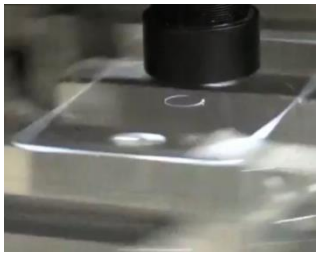
- Taper free cut
- Near net shape cutting
- High cutting speeds

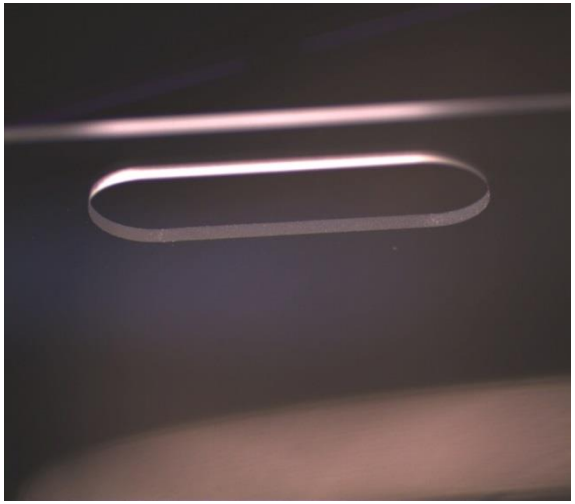
  >300mm/s in single pass
- Industrially proven
- Easy to integrate



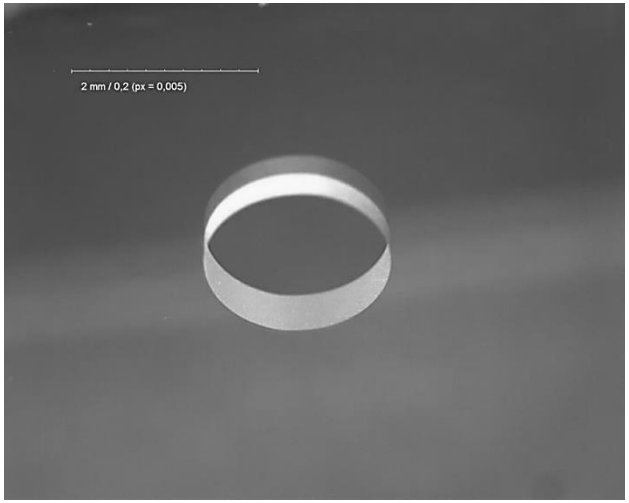
SmartCleave™FI technology

- The master piece:
  high speed production of closed (inner) contours





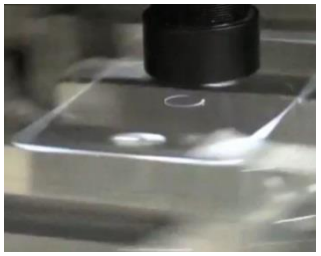
2 x 12 mm² slot in 0.55 mm thick non-strengthened sodalime-glass, v = 100 mm/s



2 mm dia. hole in 0.55 mm thick non-strengthened alumino-silicate glass, v = 100 mm/s

SmartCleave™FI technology

- The master piece:
  production of closed (inner) contours

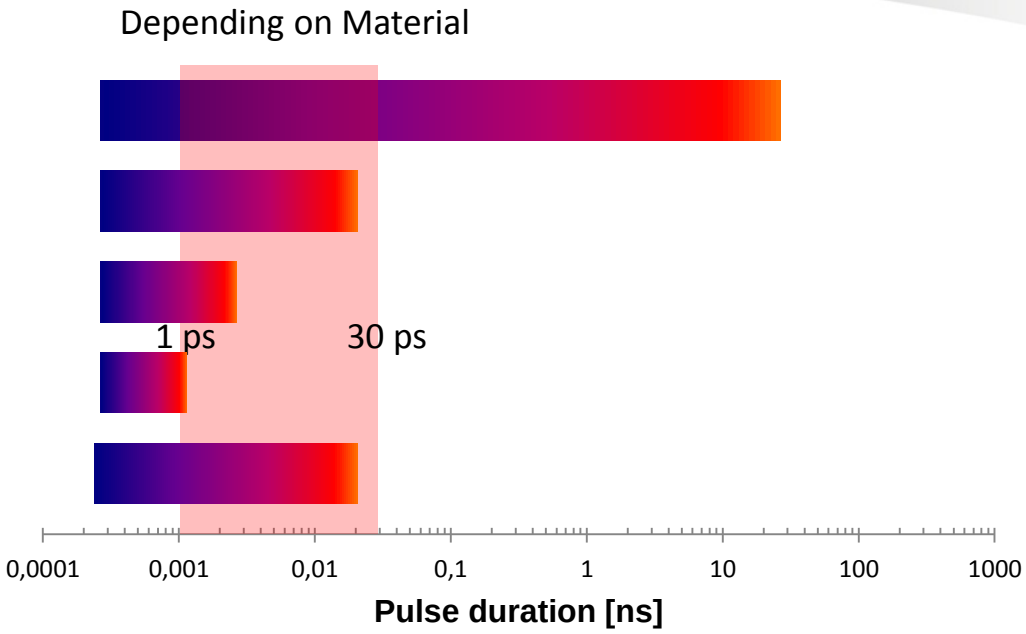


Content

- Material processing applications
- **Laser Source Requirements**
- Industrial USP Laser Solution

Pulse Width

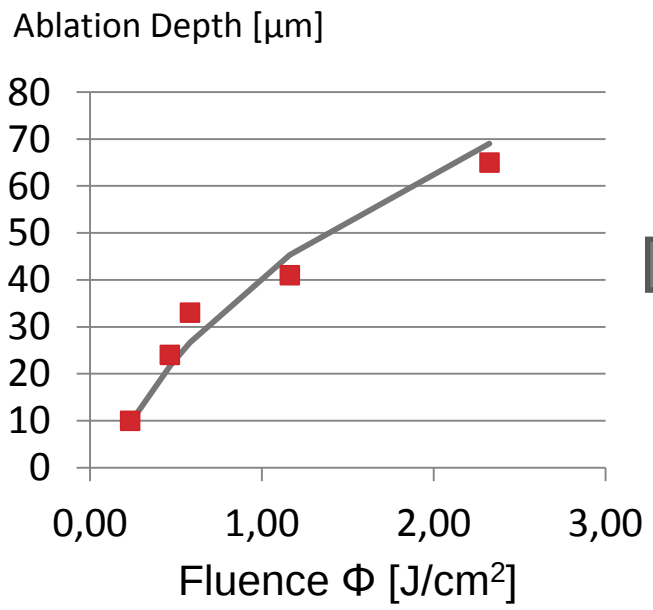
- Thin film ablation
- Engraving
- Drilling
- Fixed optics cutting
- Filamentation

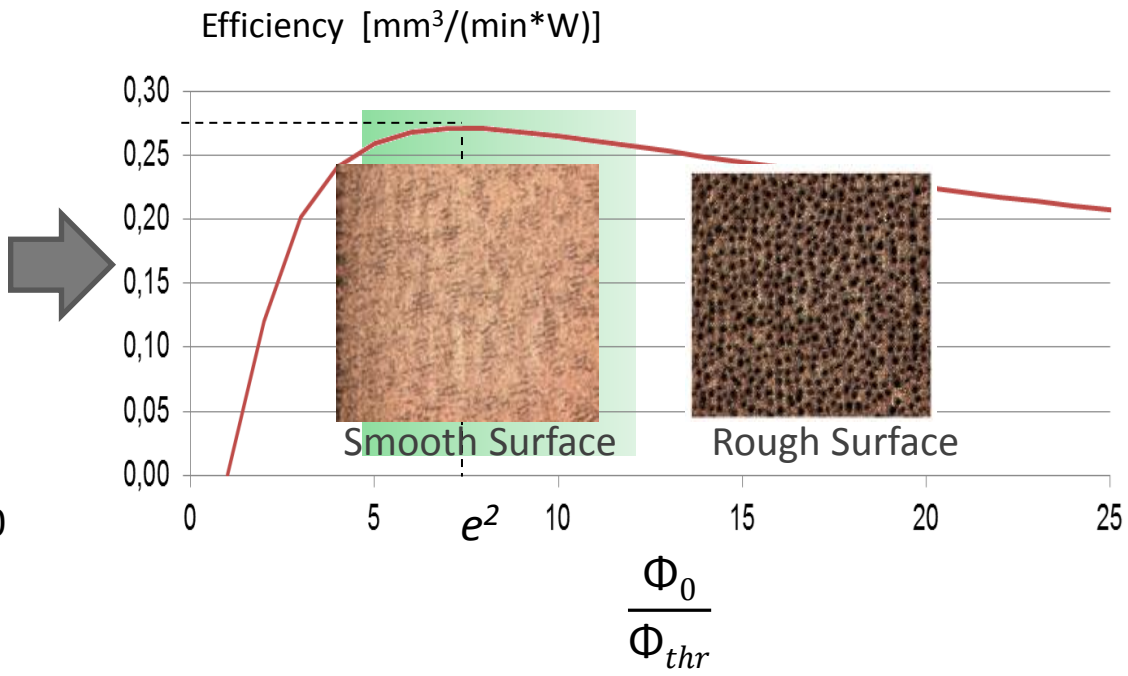


- High pulse overlap (drilling, cutting), fs pulse durations lead to best results.
- Low pulse overlap (thin film ablation, engraving) heat can be distributed by faster scanning, ps pulse widths are still a good option

→ Optimized Parameters for „Cold“ material processing 700 fs .. 20 ps

Fluence and Pulse Energy



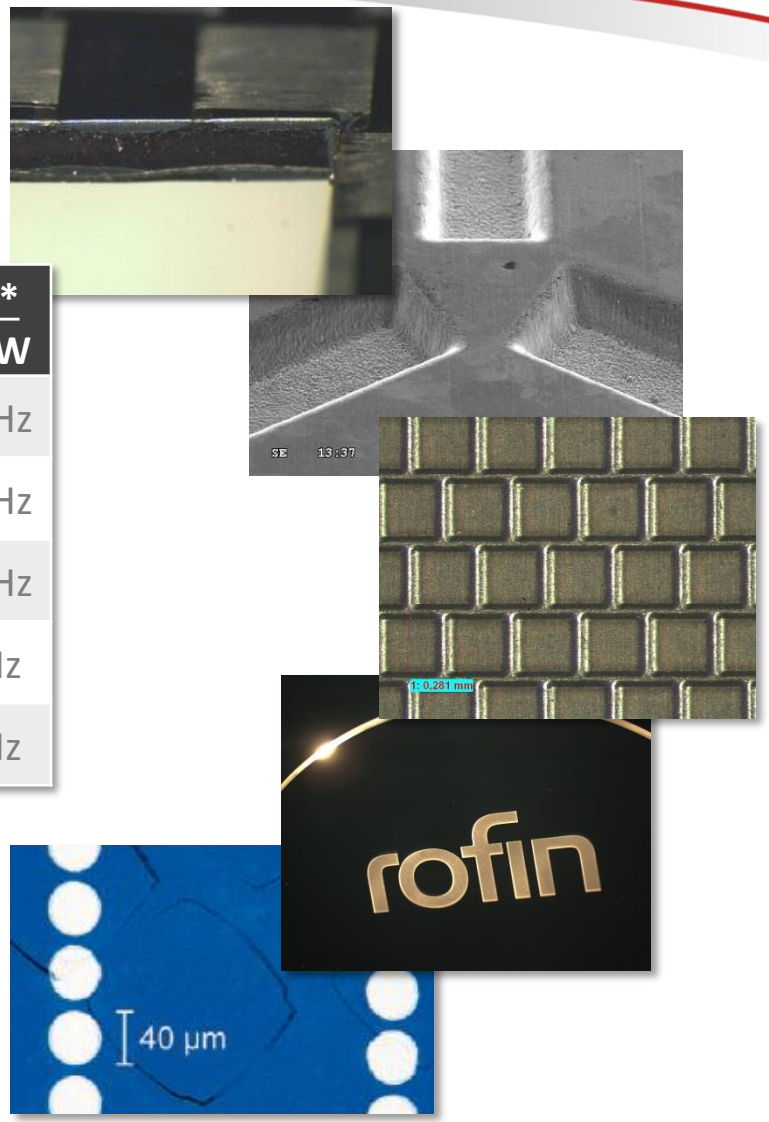


→ **Application and material properties define optimum pulse energy**

→ **Excess pulse energy will reduce quality without increasing throughput**

Repetition rates at 20W

Applications	Pulse energy µJ	Rep. Rate* kHz @ 20 W
Polymers, Composites	20 - 80	250 – 1 MHz
Cutting or drilling thick metals	20 - 80	250 – 1 MHz
Cutting or drilling thin metals	3 - 30	600 – 6 MHz
Surface engraving, marking	1 - 30	1 – 20 MHz
Thin-film removal	1 - 10	2 – 20 MHz



→ **System must be able match Rep.Rate**

* max. rep. rate available @ req. pulse energy and 20 W

Content

- Material processing applications
- Laser Source Requirements
- **Industrial USP Laser Solution**

StarFemto and StarPico

StarFemto

Pulse Width	700 fs
Pulse Energy	up to 160 µJ
Repetition Rate	Single Pulse … 2 MHz
Max. Laser Power	20 W

New

StarPico

Pulse Width	15 ps
Pulse Energy	up to 400 µJ
Repetition Rate	Single Pulse … 4 MHz
Max. Laser Power	50 W

New

Ultrashort Pulse (USP) - Lasers

Ultrashort Pulse → Cold Processing, high precision

Productivity

Reliability

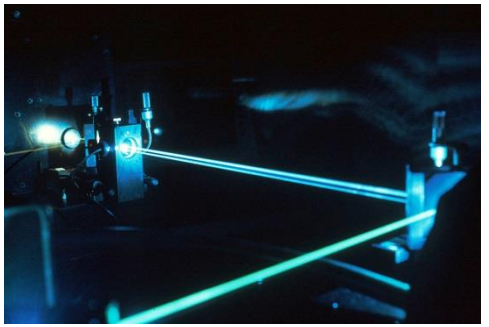
Uptime

Hybrid MOPA Product Architecture

rofin LASER MICRO

Fiber Laser Concept

Bulk Laser concept

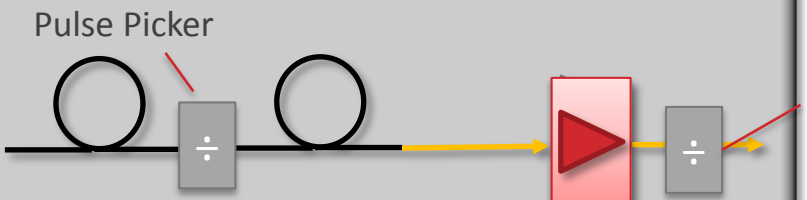


„best-of-both worlds“

Stable & Reliable Industrial Operation

Compact Footprint

ROFIN Hybrid MOPA Architecture



High Repetition Rate

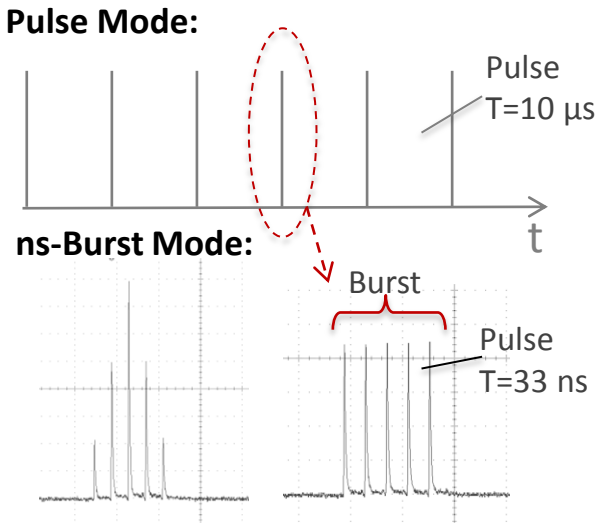
Pulse On Demand POD

High Pulse Quality

StarFemto / StarPico – Features

Patented Burst Mode

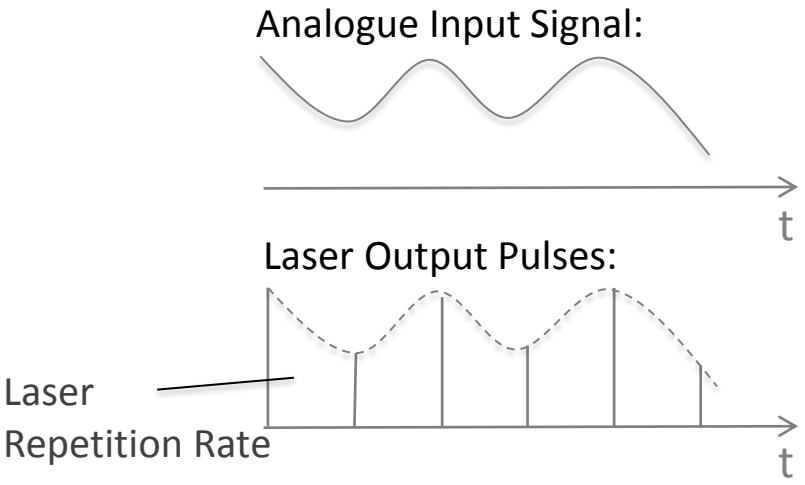
- Higher Ablation Rate
- Optimized Surface Quality
- >2mm Filaments in Glass



Fast Change of Pulse Energy

- Optimized Parameters

  for Different Process Steps
- Ensures stable pulse energy



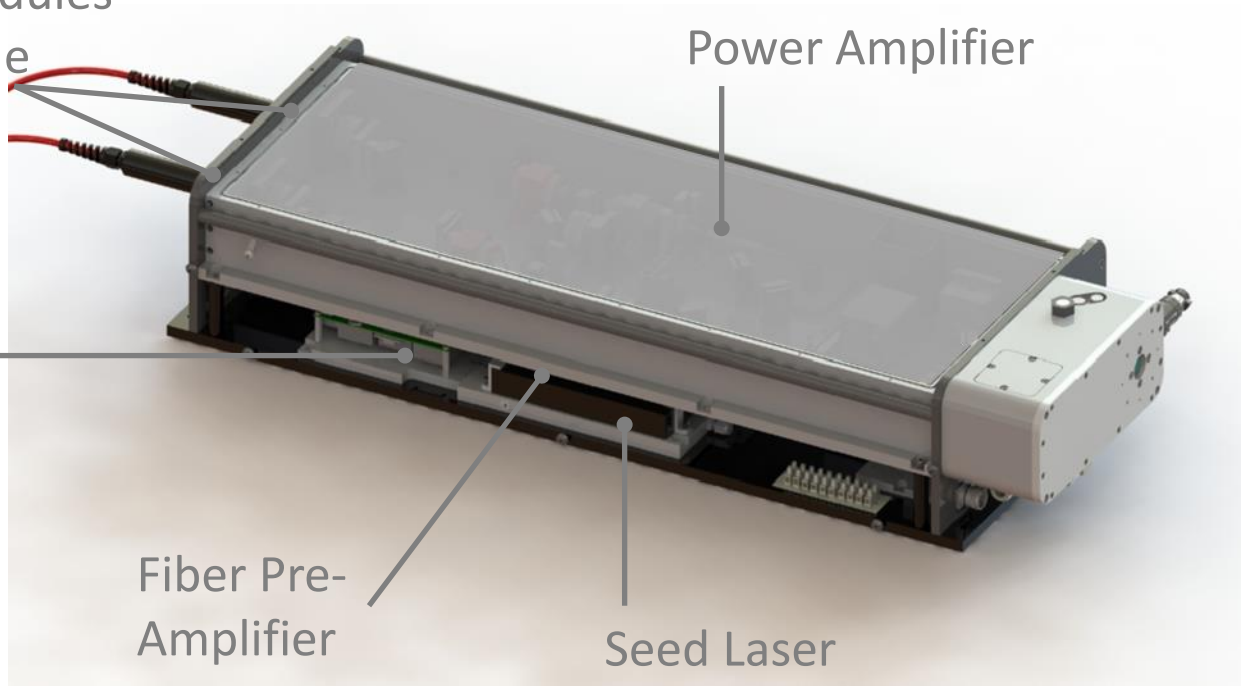
StarFemto / StarPico – Features

- Small footprint
- Integrated Safety Shutter
  - < 100 ms Back to Stable System Operation
  - According To EN ISO 13849
- Use of AOM for Pulse Picker and POD
- Hermetically sealed monolithic housing
- Field serviceable design

Rofin Service Concept

Modular Design For Field Serviceability

Fibers from Pump Modules Detachable

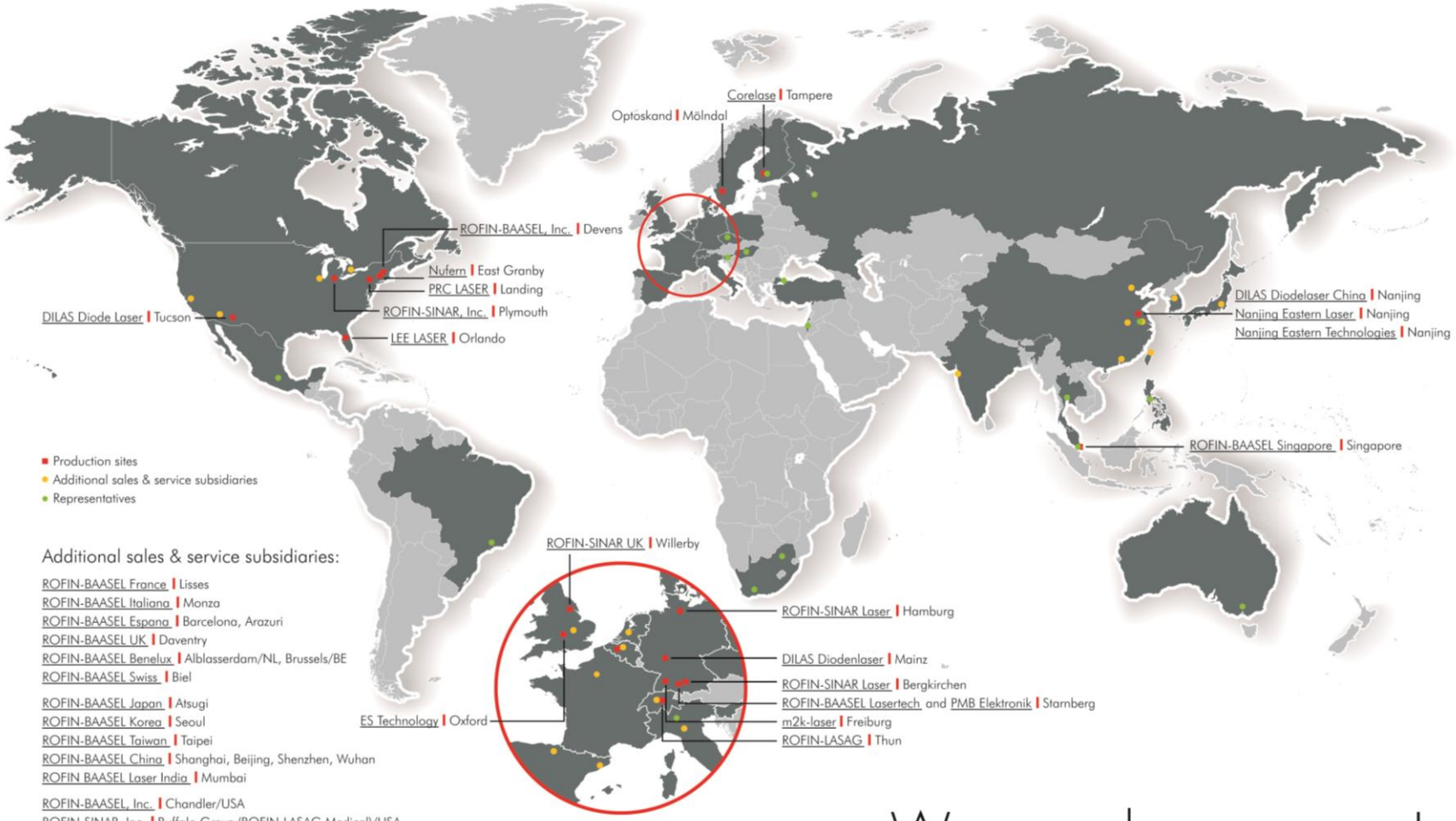


Rofin Service Concept

- Modular Setup
- Remote Access and Service
- Preventive Maintenance
- Spare part logistics concept
- Worldwide service organization

ROFIN Group
Worldwide Locations

rofin
LASER MICRO



Additional sales & service subsidiaries:

ROFIN-BAASEL France | Lisses
ROFIN-BAASEL Italiana | Monza
ROFIN-BAASEL Espana | Barcelona, Arazuri
ROFIN-BAASEL UK | Daventry
ROFIN-BAASEL Benelux | Alblasserdam/NL, Brussels/BE
ROFIN-BAASEL Swiss | Biel

ROFIN-BAASEL Japan | Atsugi
ROFIN-BAASEL Korea | Seoul
ROFIN-BAASEL Taiwan | Taipei
ROFIN-BAASEL China | Shanghai, Beijing, Shenzhen, Wuhan
ROFIN BAASEL Laser India | Mumbai

ROFIN-BAASEL, Inc. | Chandler/USA
ROFIN-SINAR, Inc. | Buffalo Grove (ROFIN-LASAG Medical)/USA
ROFIN-BAASEL Canada | Mississauga

DILAS Diodelaser | Shanghai/China

PRC Europe | Oudenaarde/Belgium
WB-PRC Laser | Zorneding/Germany

»We are where you are!

Industrial Ultrashort Pulse Solutions

rofin LASER MICRO

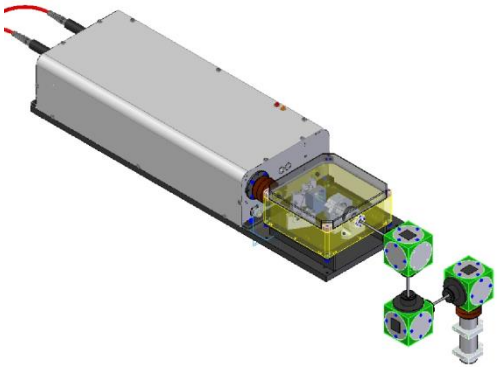
USP Laser Sources:

StarFemto
700fs

StarPico
15ps

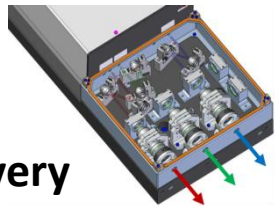
Integration Kits:

µ-Hole Drilling



SmartCleave FI
Cutting transparent & brittle material

Beam Delivery



Scanner solutions
With integrated scanner control

THANK YOU FOR YOUR ATTENTION