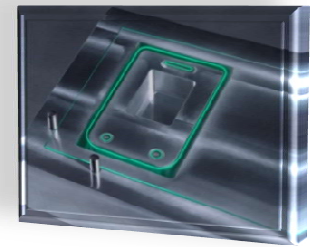




Short, Shorter, Ultrashort - Pulsed Laser: Megawatt for Micrometer



Dr. Arnd Szlagowski
Director Research & Development
TRUMPF Maschinen AG; Baar

Swiss Laser Microprocessing Solutions, 12.06.2013, Geneva



Agenda

Facts about TRUMPF

Advantages of ultra short pulses

Laser micro application with ultra short pulsed lasers



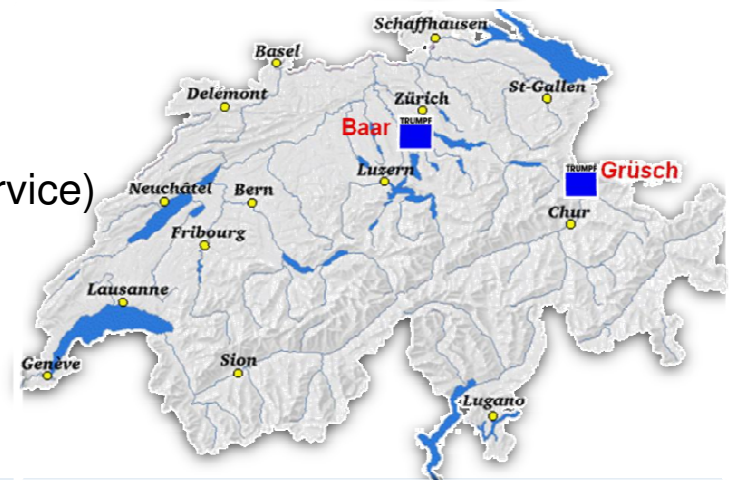
Facts about TRUMPF

The TRUMPF Group is a technology and world market leader for industrial lasers and laser systems for sheet metal processing with emphasis on

- Cutting & Welding
- Marking & Micromachining (ablation, drilling, patterning, ...)





- Family business since 1923
- Approximately 9500 employees worldwide
1350 employees in R&D
- 58 subsidiaries worldwide (R&D, Sales & Service)
CH locations: Grösch and Baar

<http://www.ch.trumpf.com/>





TRUMPF Group Business Divisions

Machine Tools		Laser Technology/ Electronics		Medical Technology	
Machine Tools		Laser Technology	Electronics	Medical Technology	
					
Machine tools for flexible sheet metal and tube processing, Power tools for sheet metal processing		Lasers for production technology	Power supplies for induction heating, plasma and CO ₂ laser excitation	Surgical lights, operating tables, video solutions, supply systems	
Sales (mil €)	1,890	Sales (mil €)	727	Sales (mil €)	184
Employees	5,918	Employees	2,330	Employees	713

Revenue FY 11/12 € 2.8 billion (2/3 with laser technology)

End of fiscal year: June 30, 2012; consolidated within the business division; figures rounded



Agenda

Facts about TRUMPF

Advantages of ultra short pulses

Laser micro application with ultra short pulsed lasers



Time Scales: How short is „ultrashort“?

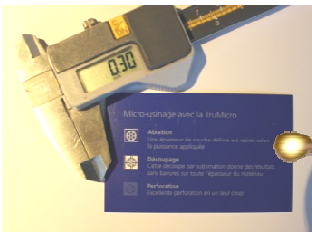
1 Second (s) = 10^{-0} s = 1 s

1 Millisecond (ms) = 10^{-3} s = 0,001 s

1 Microsecond (μ s) = 10^{-6} s = 0,000 001 s

1 Nanosecond (ns) = 10^{-9} s = 0,000 000 001 s

1 Picosecond (ps) = 10^{-12} s = 0,000 000 000 001 s

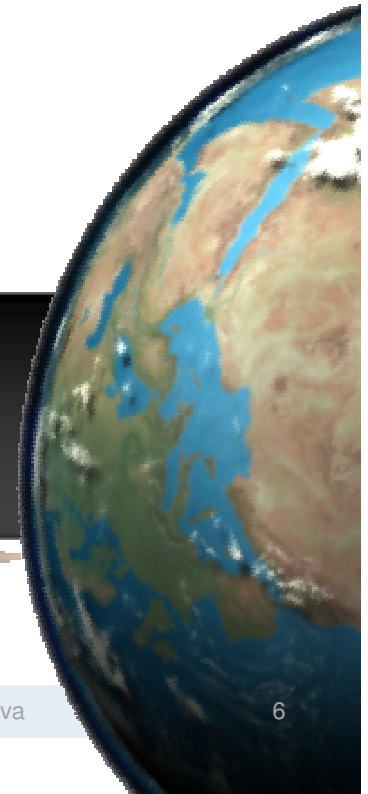


Speed of light: 300 tsd. km / Second bzw. 0,3mm / ps*

TruMicro 5000 pulse \approx 2 mm

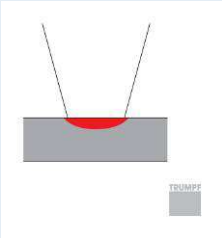
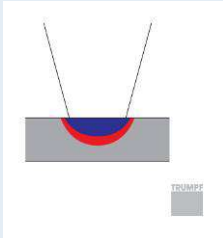
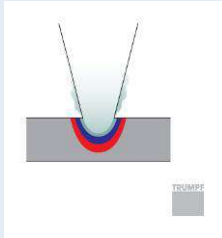
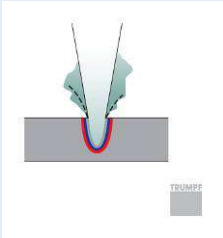
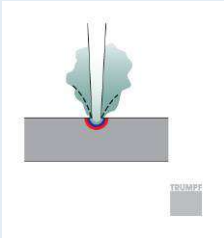
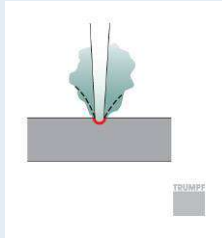


* \approx distance earth - moon / 1 second





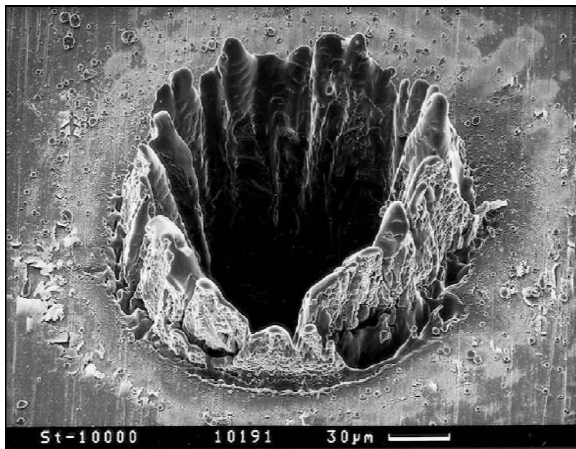
Influence and effect of high power density

						
Main effect	heating	melting	melting and vaporizing	vaporizing	vaporizing & ionization	sublimation & direct dissociation
Power density	30 W/mm ²	1 kW/mm ²	10 kW/mm ²	1 MW/mm ²	10 MW/mm ²	10 GW/mm ²
Application time	s	ms	ns-ms	ns-ms	ns	ps
Process examples	hardening, soldering	heat conduction welding	deep welding, cutting	drilling	ablation, marking	structuring

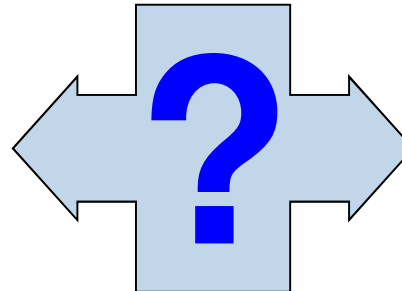


Why shorter than short?

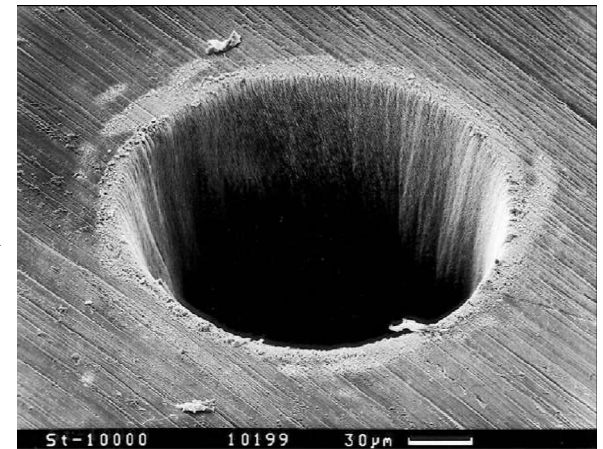
ns pulse



- Melt discharge
- heat affected zone (HAZ)
- limited accuracy
- high throughput



fs pulse



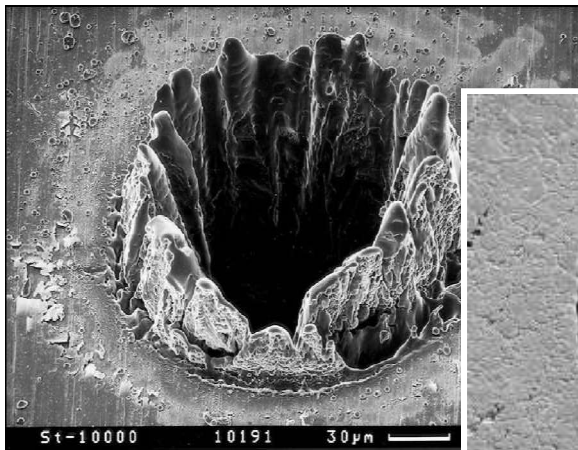
- perfect quality
- high accuracy
- relatively slow

C. Momma, B.N. Chichkov, S. Nolte, F. von Alvensleben, A.; Tünnermann, H. Welling, B. Wellegehausen, "Short-pulse laser ablation of solid targets", Opt. Commun. **129**, 134 (1996)

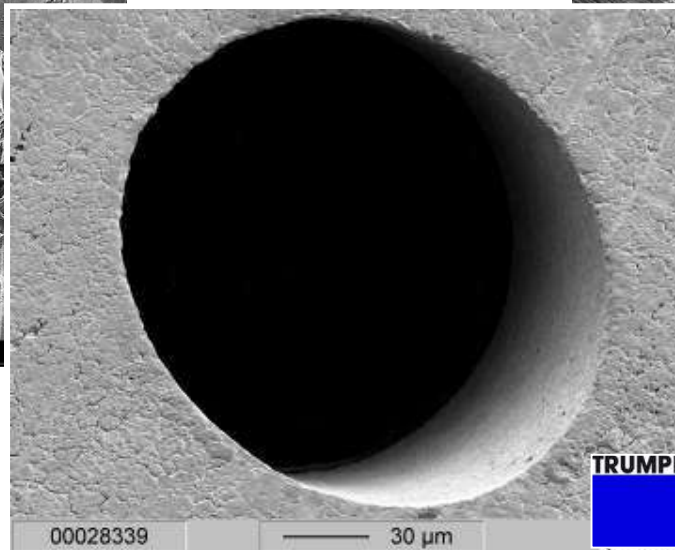


Why shorter than short?

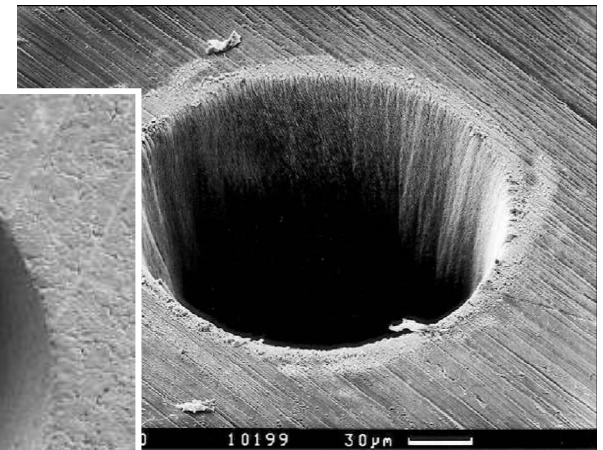
ns pulse



ps pulse



fs pulse



Drilling of holes in stainless steel with TruMicro 5050

C. Momma, B.N. Chichkov, S. Nolte, F. von Alvensleben, A.; Tünnermann, H. Welling, B. Wellegehausen, "Short-pulse laser ablation of solid targets", Opt. Commun. **129**, 134 (1996)



TruMicro Laser Portfolio



NEW



Current: 6 ps
new 800 fs-Edition



TruMicro	2000	3000	5000	7000
Pulse width	ps	ns	ps to fs	ns
Max. Average power	IR: 10 W Green: 6 W	IR: 12 W Green: 8 W	IR: 150 W Green: 100 W UV: 15 W	IR: 850 W Green: 300 W
Max. Pulse Energy	IR: 10 μ J Green: 6 μ J	IR/Green: 300 μ J	IR: 250 μ J Green: 125 μ J UV: 37.5 μ J	IR: 80 mJ Green: 7.5 mJ
Beam delivery	Direct beam	direct beam	direct beam	fiber coupled
Typical application	Foil cutting, black marking, ablation	Solar Cell structuring (P1-3)	Precision drilling, cutting and ablation	High speed ablation, cutting and drilling

NEW



Agenda

Facts about TRUMPF

Advantages of ultra short pulses

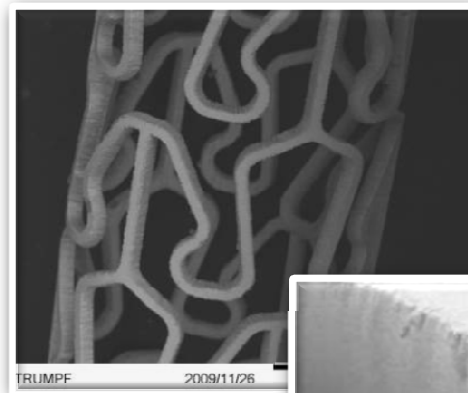
Laser micro application with ultra short pulsed lasers



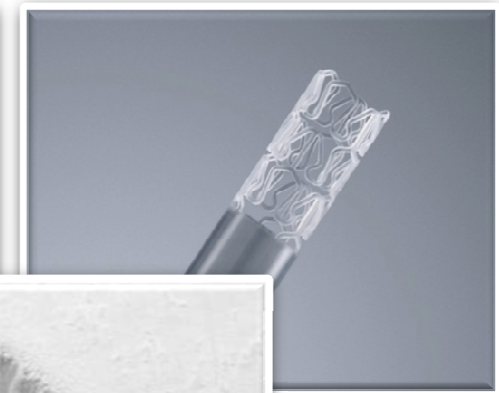
Competence field: stent cutting

- Wide spread of materials:
 - Stainless steel
 - Nitinol
 - Polymer
 - Bioresorbable materials (e.g. Mg)

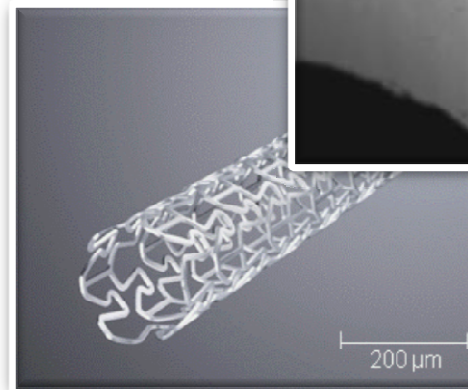
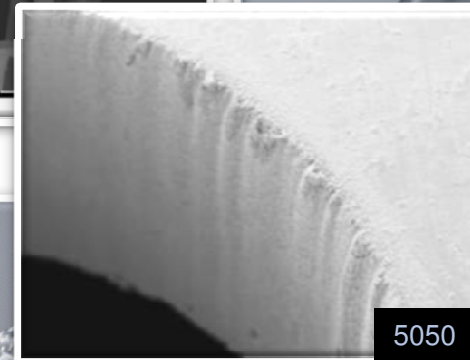
- Highest precision
 - Negligible burr formation
 - Negligible HAZ
 → Reduction of expensive finishing processes / rework



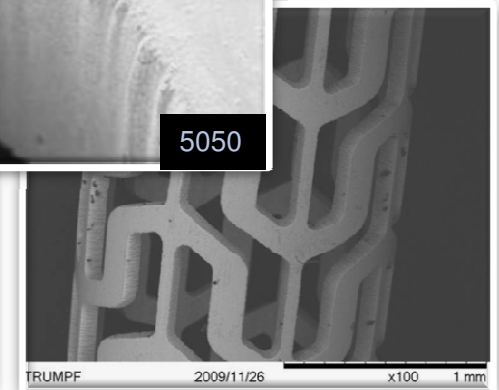
Nitinol



Polymer



Stainless steel

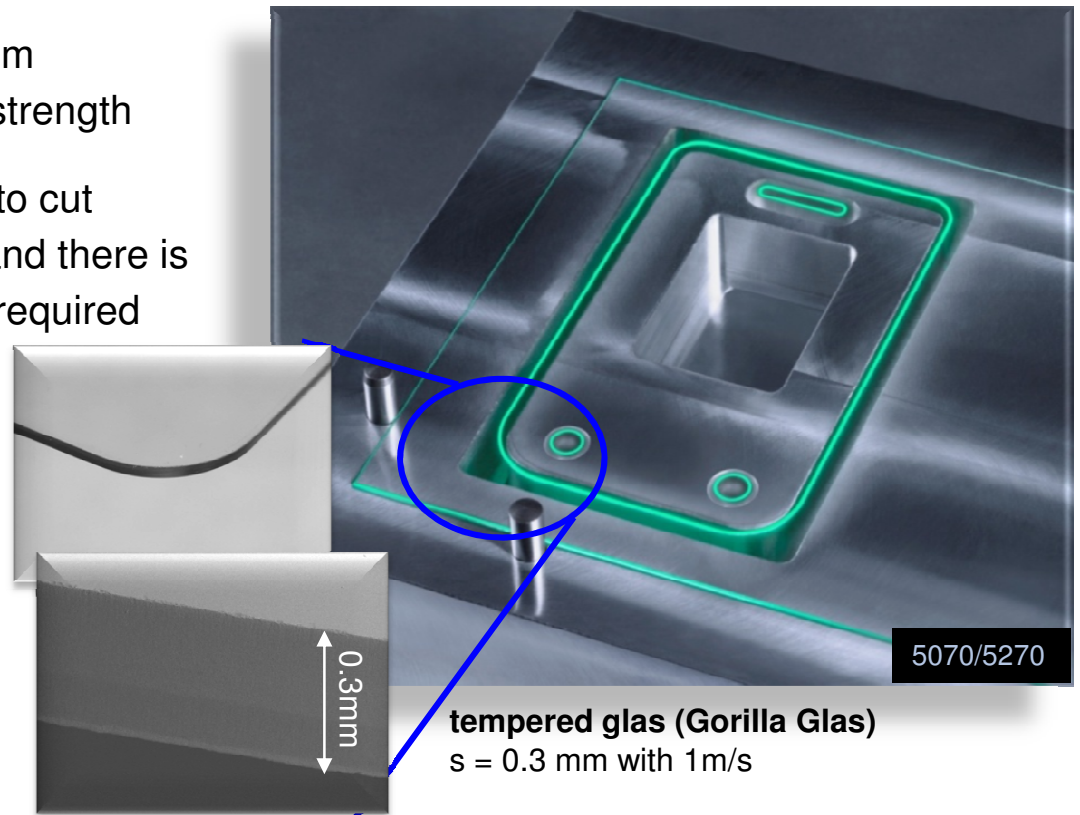


CrCo



Competence field: Cutting of tempered glass

- Corning Gorilla glass (cover / safety glass)
- typical thickness: 0.3 - 0.7mm
→ extremely thin with high strength
- conventionally very difficult to cut (milling, chemical etching) and there is an extremely high finishing required
 - reduce rework
 - no thermal strain = no cracks
 - high flexibility in contour

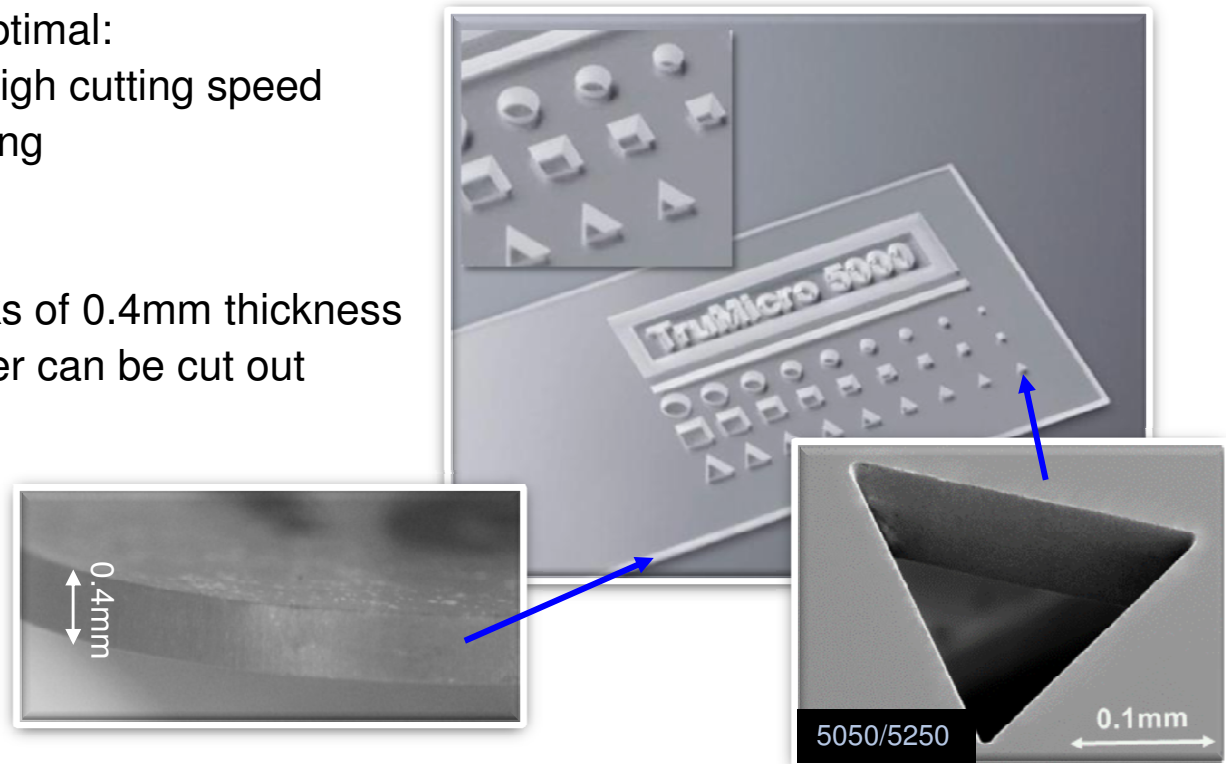


tempered glas (Gorilla Glas)
s = 0.3 mm with 1m/s



Competence field: Precision cutting of Sapphire

- Cutting Sapphire (cover glass of watches) with conventional technology difficult
- USP-Laser are optimal:
 - high quality & high cutting speed
 - no micro cracking
 - no chipping
- With IR laser disks of 0.4mm thickness and 5mm diameter can be cut out in less than 5s .



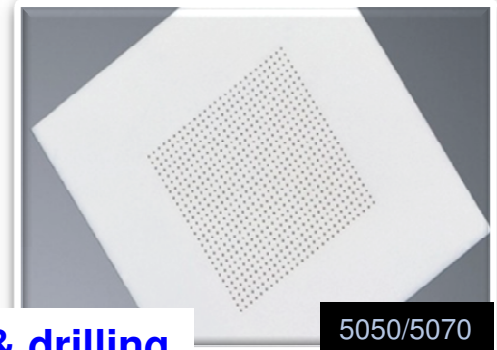
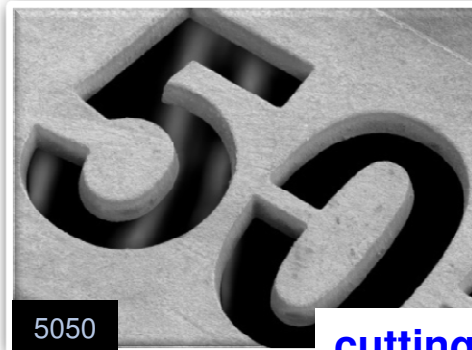
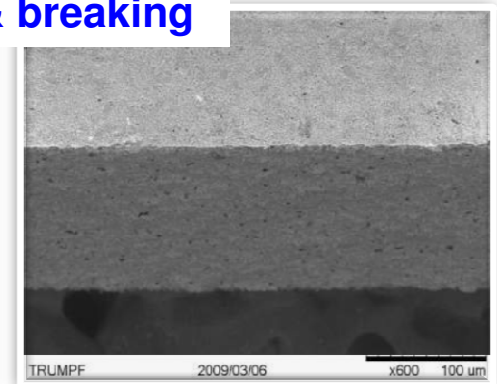
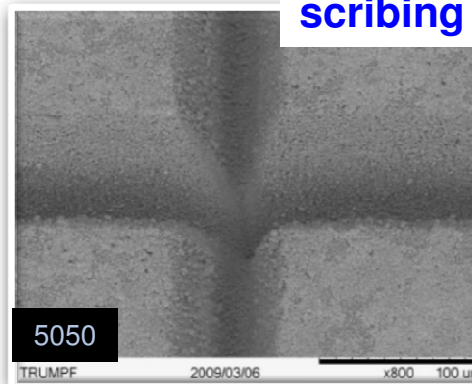


Competence field: micro processing of ceramics

- cutting, drilling or scribing & breaking of brittle Material
e.g. Alumina (Al_2O_3) or AlN
- 1/3 of thickness scribing,
afterwards breaking

- excellent edge quality
- small kerf (<20 μ m)
- high precision
- low abrasion compared to
mechanical processing

scribing & breaking



cutting & drilling

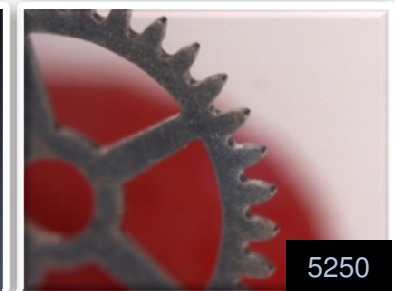
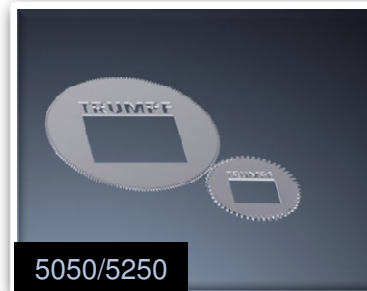


Competence field: Precision cutting of metal

Samples from watch maker industry

- needles
- clock faces
- gears
- anchors...

- no thermal and mechanical influence
- no burr
- variance of material (Aluminum, bronze, gold, stainless steel, copper, brass...) with thicknesses $\geq 10\mu\text{m}$



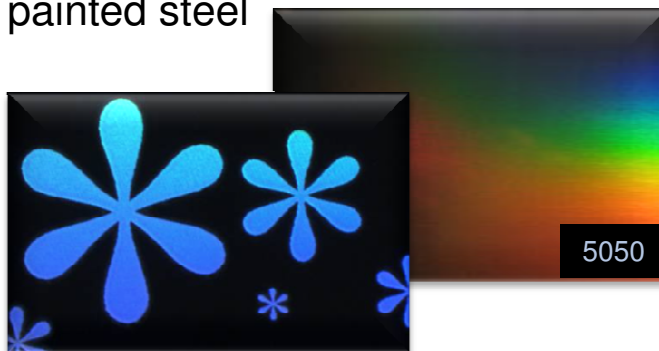


Competence field: Design

- Perforating of leather with high quality



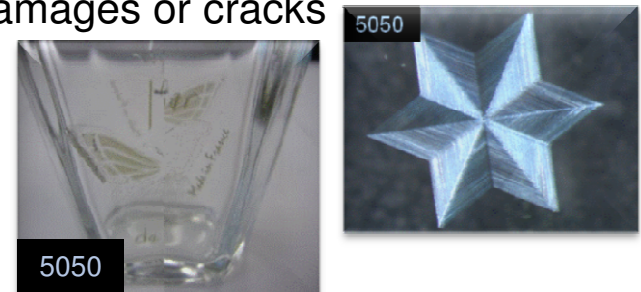
- Lacquer removal: rainbow effect on black painted steel



- Blackmarking of anodized aluminum



- Marking of glass without thermal damages or cracks





Abstract

- USP are the key for cold material processing
 - no HAZ with ps pulses
- High quality results: no burr or dross
 - rework is avoided or reduced to minimum
 - small cutting kerfs
- Perfect processing of wide spread of material
 - one tool for different materials
 - design flexibility of contours
- Installation of hundreds of TruMicros in production engineering environment (24/7)
- TRUMPF has a worldwide application Lab Network for micro application tests
 - next lab in Baar in co-operation with CSEM Alpnach



TRUMPF



TRUMPF:
***We are not selling only a product,
but solutions!***



***Come and see TruMicro 5070
in action at our booth D95!***

Dr. Arnd Szelagowski
Director Research & Development
TRUMPF Maschinen AG; Baar
arnd.szelagowski@ch.trumpf.com