RAZipol

Project presentation

Ultrafast Lasers with Radial and Azimuthal Polarizations for High-efficiency Micro-machining Applications

The Ultrafast_RAZipol project has received funding from the European Community's Seventh Framework Programme under Grant Agreement No. 619237

SEVENTH FRAMEWORK PROGRAMME

Beneficiaries – Call Topic Objective ICT-2013.3.2 Photonics iii) Laser for Industrial processing

Time-Bandwidth Products AG - Switzerland

Class 4 Laser Professionals AG - Switzerland

Next Scan Technology BV - Netherlands

Universität Stuttgart - Germany

GFH GMBH - Germany

Centre National de la Recherche Scientifique - France

Schweisstechnische Lehr- Und Versuchsanstalt SLV Mecklenburg- Vorpommern - Germany

Fibercryst SAS - France

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Project motivations

- High-precision laser micro-machining has delivered a tremendous impact in daily life:
  - Manufacture of smart phones, i-tablets, etc,
  - In the car industry it is has been shown that diesel nozzles produced with ultrafast lasers lead to significantly reduced air pollution in comparison to nozzles produced with conventional fabrication techniques.
  - Spinning nozzles used widely in the textile industry are also produced using ultrafast lasers.

- The main goal of RAZipol is to demonstrate laser material processing at unprecedented levels of productivity and precision material processing using beams with novel radial and azimuthal polarization

  - Challenges: high-productivity and high-quality at the same time
  - Therefore ultrafast laser source with a very high average power and well-adapted beam parameters (pulse width, intensity profile, repetition rate and polarization) is needed

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Project aims

- The following primary objectives have to be targeted:
  - Highly flexible high-power ultrafast laser source (objective 1) with average output power of 500 W1 at High Repetition Rates (20-40 MHz) and 200W2 at Low Repetition Rates (0.2-1 MHz)
  - Cost-efficient solutions for a broad range of applications (objective 2)
  - Optimization of demanding high-volume applications regarding efficiency as well as quality (objective 3)
- Within the project, mainly two attractive applications shall be investigated to demonstrate the potential of the source:
  - Fast, large-area structuring, of Lab-on-a-Chip wafers
  - Precision trepanning drilling of high-aspect ratio holes

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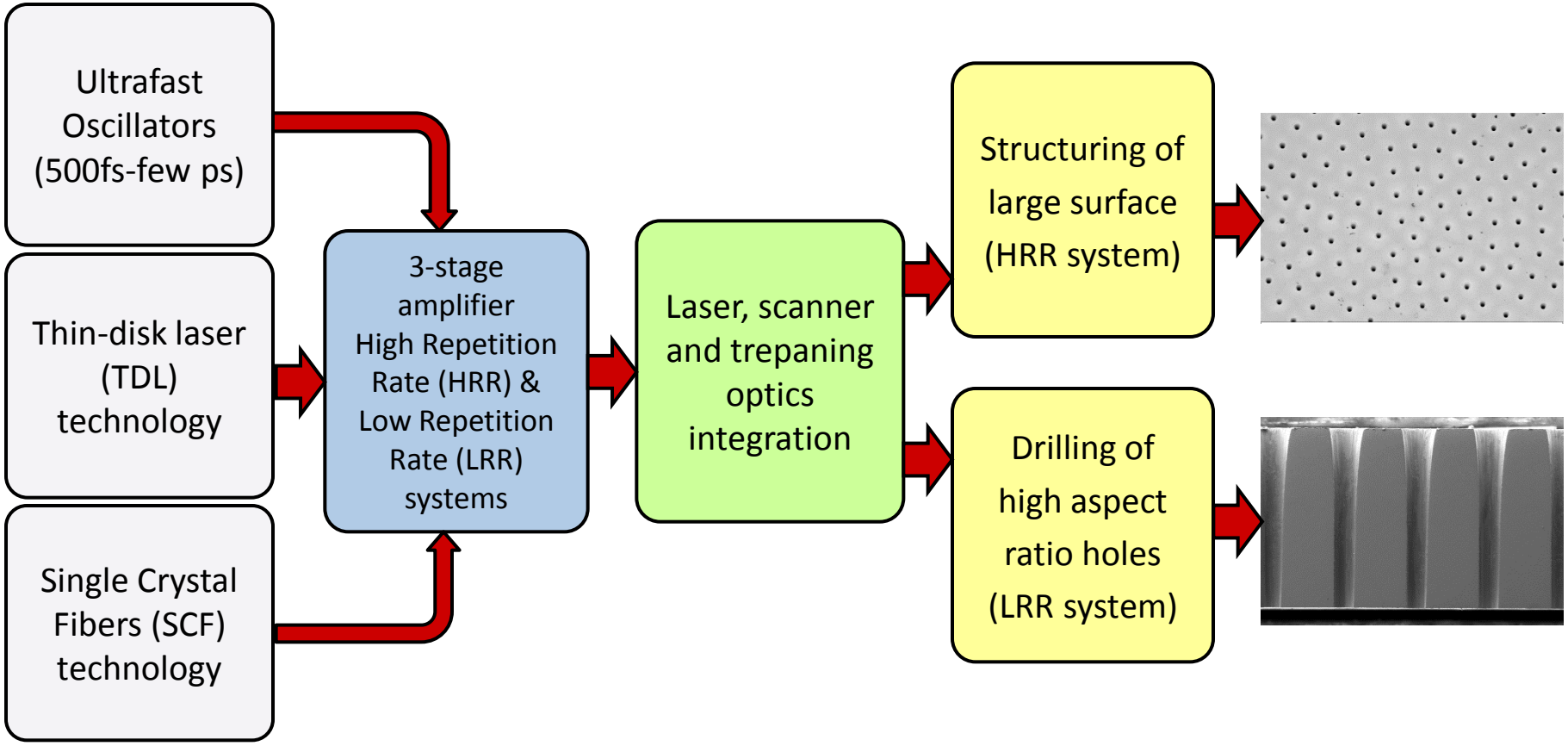
Overview project structure



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Project objectives

- Ultra-fast oscillators (WP1)
  - High repetition rate (HRR) oscillator: P_{out} = 3W, Rep. rate: 20-40MHz, pulse duration: 500fs
  - Low repetition rate (LRR) oscillator: P_{out} = 3W, Rep. rate =20-40MHz, pulse duration: 3-5ps + pulse picker for rep. rate: 0.2-1MHz, Tuning range: 5-10 nm.
- Single Crystal Fiber (SCF) amplifiers (WP2)
  - High repetition rate (HRR) system: P_{out} = 70W (100W), Rep. rate: 20-40MHz, pulse duration: 1ps
  - Low repetition rate (LRR) system: P_{out} = 35W (70W) , Rep. rate: 0.2-1MHz, pulse duration: 5ps

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Project objectives

- Thin-disk multipass amplifiers (WP3)
  - High repetition rate (HRR) system: P_{out} = 500W, Rep. rate: 20-40MHz, pulse duration: 1ps
  - Low repetition rate (LRR) system: P_{out} = 200W, Rep. rate: 0.2-1MHz, pulse duration: 5ps
- Systems and machine integrations (WP1, 4 and 5)
  - 200 mm polygon scanners with up to 300m/s scanning speed
  - Trepanning optics
- Large Surface structuring and drilling applications (WP6)
  - Large surface structuring (HRR system)
    - Min. structure size: <1µm, aspect ratio: 1:1, depth: 0.1- 50µm, Surface ablation speed: 20cm²/min
  - Drilling of high aspect ratio holes (LRR system)
    - Min. structure size: 50µm, aspect ratio: 40:1, depth: 2mm, processing time: <4s

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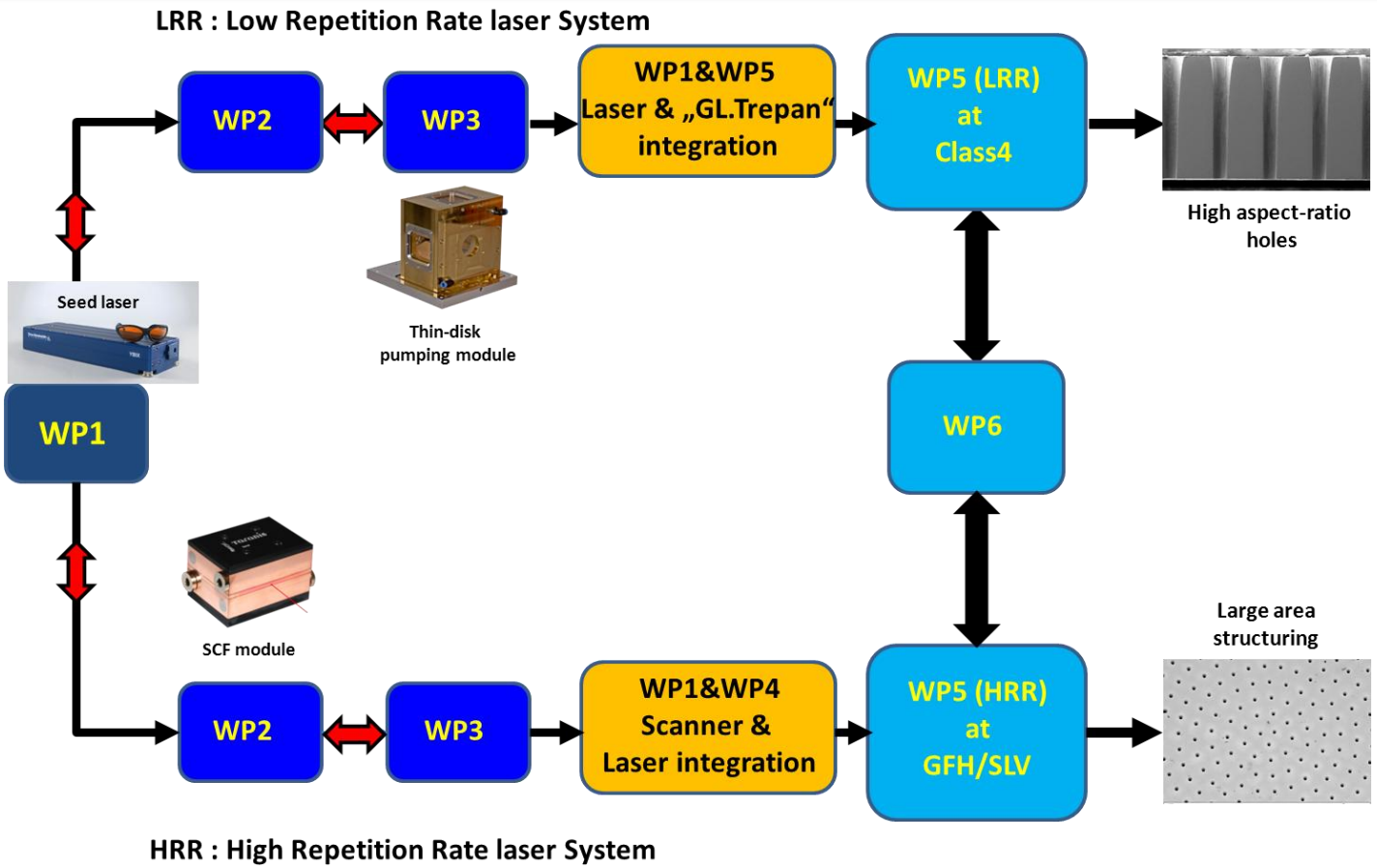
Overview work package structure



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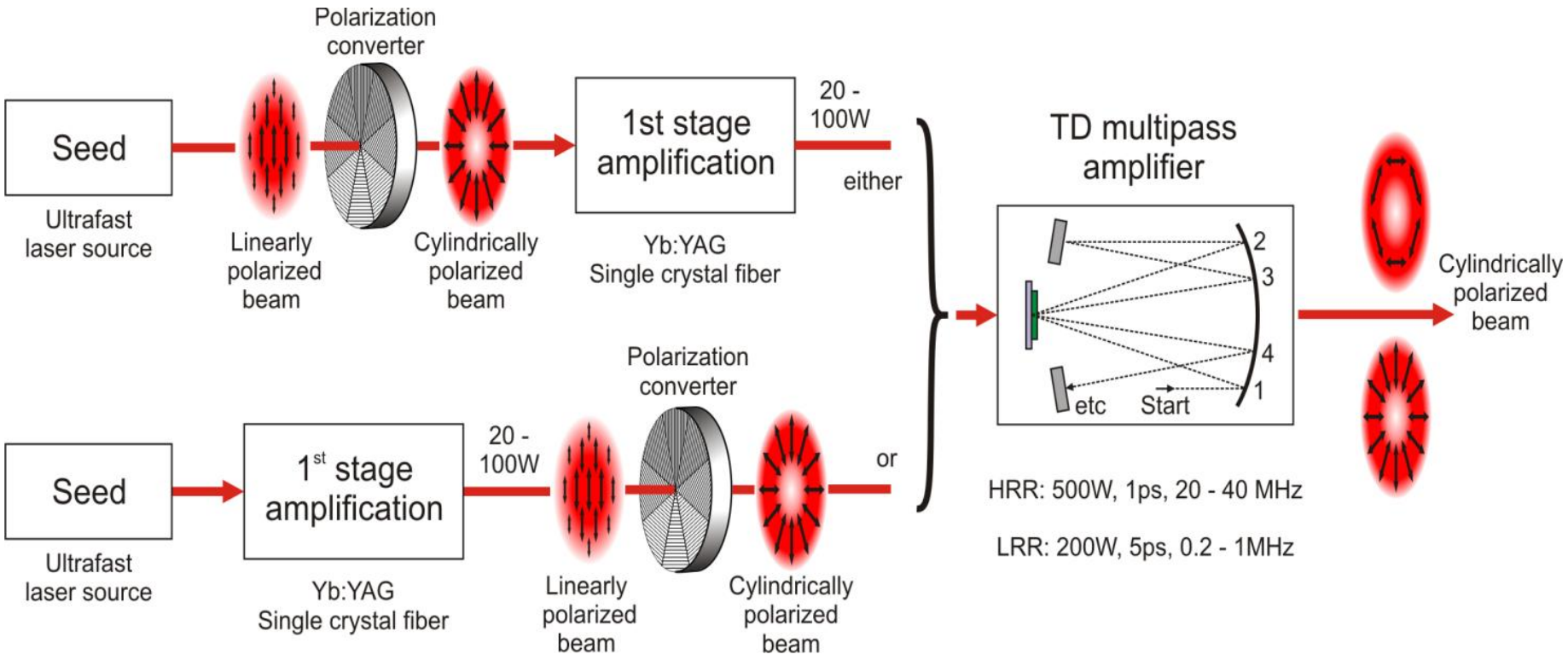
Project concept



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Project expected results – HRR application benchmarking parameters

	Industrial SOA				Scientific SOA	Razipol expected results
	ps Laser (SLV)	Photolithography / lift off	comment	Photolithography / lift off using chromium masks	ps-laser	
Responsible:						
Min. Structure size	< 5µm	3 µm		0.2 µm	< 1µm	< 1µm
Aspect ration	1:1	1:1		1:1	1:1	1:1
Depth	1 – 10µm	0.1 – 0.5 µm		0.1 – 1 µm	0.5 – 10µm	0.1 – 50µm
Surface Roughness	< 1µm	< 0.05 µm		< 0.05 µm	< 0.5µm	< 0.5µm
Volume Ablation Rate	< 1mm³/min	-			2.5 nm³ / min	> 20mm³ / min
Surface Ablation Rate	1cm² / min	10 – 100 nm / min		10 – 100 nm / min	2.5 cm² / min	> 20cm² / min
Cost	-	150-200 € / chip	*incl. pH-sensor*	250-400 € / chip	70 € / chip	< 20 € / chip
Figure of Merit	Processing time				Ablation rate	
Benchmark process: Lab on Chip						

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Project expected results – LRR application benchmarking parameters

	Industrial SOA			Scientific SOA		Razipol expected results
	ps Laser (SLV)	EDM	comment	ps-laser (ILT and IFSW)	Comment	
Min. Structure size (Diameter)	< 40µm	50µm		>50µm / <50µm		< 50µm
Aspect ration	1:10 / 1:30	1:14		1:40 / 1:20		1:40
Depth	< 1.2mm	0.7mm		2mm / 1mm		2 mm
Tapering	-5° / +5°	-1° / +2°		-4°-+3°/-8°-+8°	*edge angle*	-10° / 10°
Roundness	> 92%	> 96%		>90% / >96%		> 95%
Surface Roughness	< 0.3µm	< 0.3µm	*Micro cracks*	< 1µm /<0.5µm		< 0.3µm
Cycle time	< 6s	37s / 10s	*Single hole/ parallel processing*	25s / 10s	*>50µm / <50µm diameter*	< 4s
Cost	< 1€ / hole	-		-		-
Figure of Merit	cpk ≥ 1.2, flow tolerance ≤ 1.5%	Flow tolerance ≤ 3%		process duration		
Remark:	*The parameters cannot be all achieved in a single process.*					
Benchmark process: Nozzle drilling, depth 1to2mm, diameter <50µm, drilling time <4s, material: stainless steel						

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