

Advances of multi kHz picosecond laser systems for SLR

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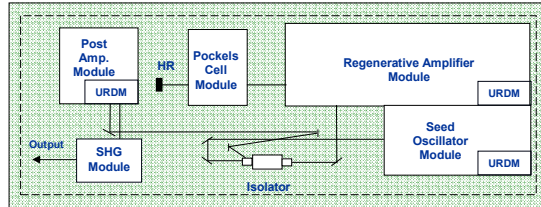
What is the goal of an ultra fast laser system?



- Generate short pulses: ca. 10ps
- Amplification to high energies (~mJ) at high repetition rates (~kHz)
- Conversion to visible: Blue 435nm; Green, 527/532nm
- High power stability: < 1% RMS
- High pulse-to-pulse stability: <1% RMS
- Beam quality: $M^2 < 1.5$
- Robust and compact overall system



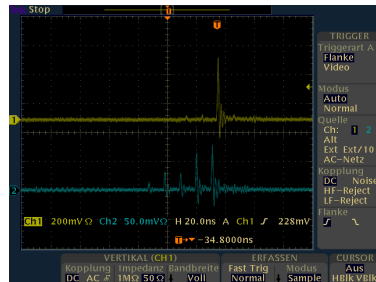
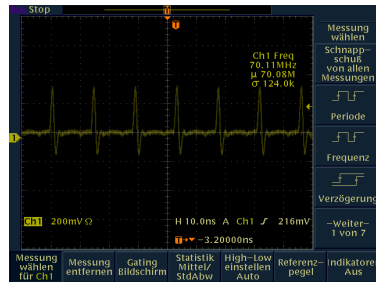
***pico*REGEN: Picosecond diode pumped oscillator / regenerative amplifier / post amplifier laser system**

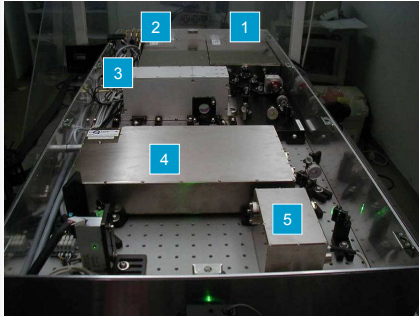


- Wavelength 1064nm internal/532nm
- Pulse duration 12ps
- Average power max. 0.8W
- Pulse energy 0.5mJ@1kHz; 0.4mJ@2kHz
- Repetition rate single pulse to 2kHz
- Robust, monolithic, all-in-one system, no external pump lasers

REGEN – Pulse Generation and Amplification

- First the ultra short pulse is generated
 - Seed laser oscillator signal
- Then it is amplified in a regenerative amplifier
 - REGEN output laser pulse and internal build up signal

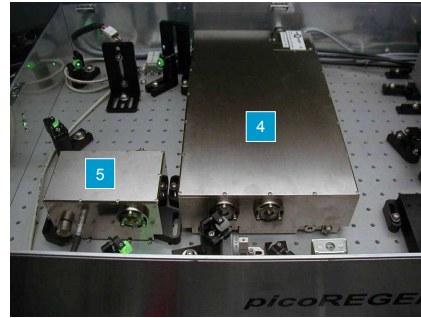




Strictly modular set-up:

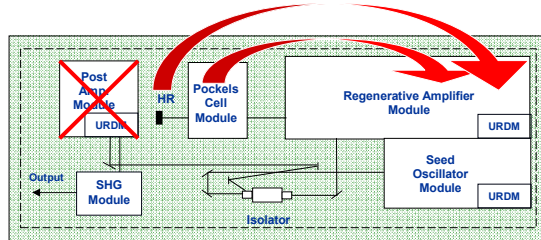
1. Seeder
2. Regenerative amplifier
3. Pockels – cell
4. Post-amplifier
5. SHG module

Post-amplifier and SHG module



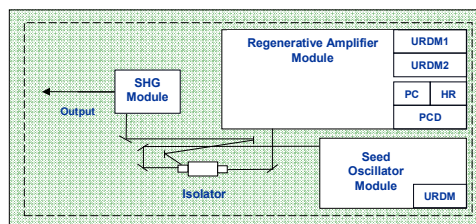
- Scientists input: Higher pulse energy **>3mJ@1kHz** and **>1.5mJ@2kHz** in IR (1.2mJ@1kHz; 0.6mJ@2kHz in VIS)
- But: Limitation from laser material Nd:VAN
 - Laser state life time: ca. 200µs
 - Single pass gain: 2-3
 - REGEN + post amplifier
- Change of laser material to Nd:YLF
 - Laser state life time: ca. 550µs
 - Single pass gain: 1.5
 - REGEN only concept

picOREGEN: Picosecond diode pumped oscillator / regenerative amplifier / post amplifier laser system



- Avoiding post amplification module due to higher laser state life time = energy storage capability
- Mechanical integration of end mirror (HR) into REGEN module
- Mechanical integration of Pockels cell module into REGEN module

picOREGEN: Picosecond diode pumped oscillator / regenerative amplifier laser system



- Wavelength 1053nm internal/527nm
- Pulse duration 8ps
- Average power 1.2W
- Pulse energy 1.2mJ@1kHz (2.4x increase); 0.6mJ@2kHz
- Repetition rate single pulse to 2kHz, optional to 50kHz
- Robust, monolithic, all-in-one system, no external pump lasers

Advances of the new IC-527-1200



- No post amp (Nd:VAN 532nm → Nd:YLF 527nm)
- End mirror HR integrated in REGEN module → no realignment
- Pockels cell integrated
- Pockels cell driver integrated, can be exchanged without optical realignment
- Two fiber coupled URDMs (30W, 805nm) → Easy exchange
- Higher repetition rate:
 - up to 2kHz: Pulsed pumping, 650μs
 - 2kHz to 50kHz: CW pumping

REGEN module 3D view



- Monolithic set-up
- 20mm massive aluminum base plate / temp. stabilized
- Sealed-off enclosure
- Class 100 clean room manufactured

REGEN module top view

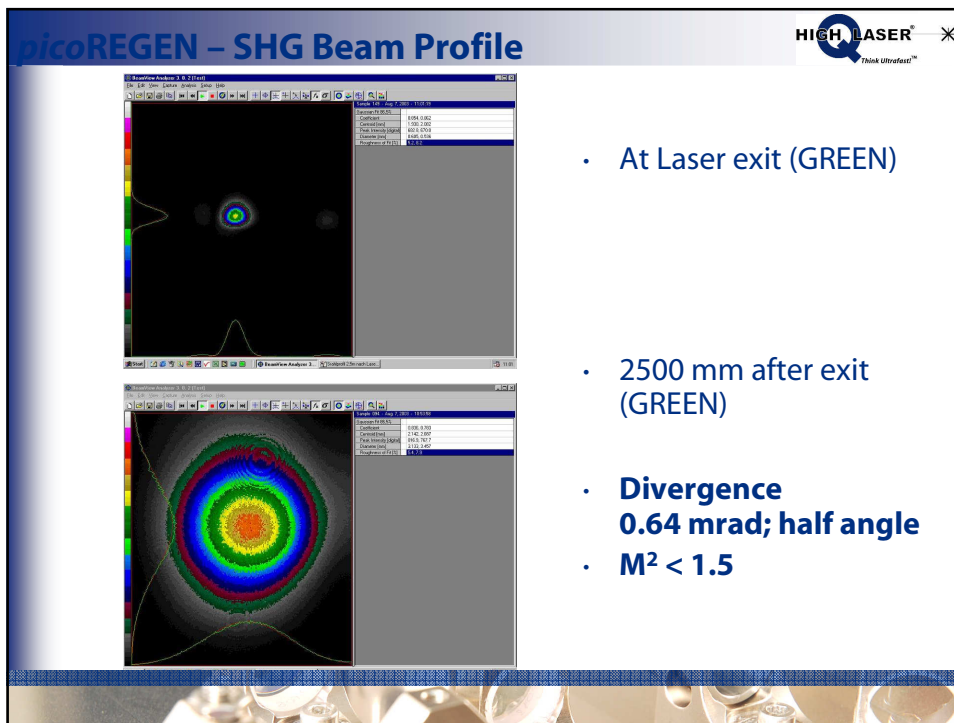
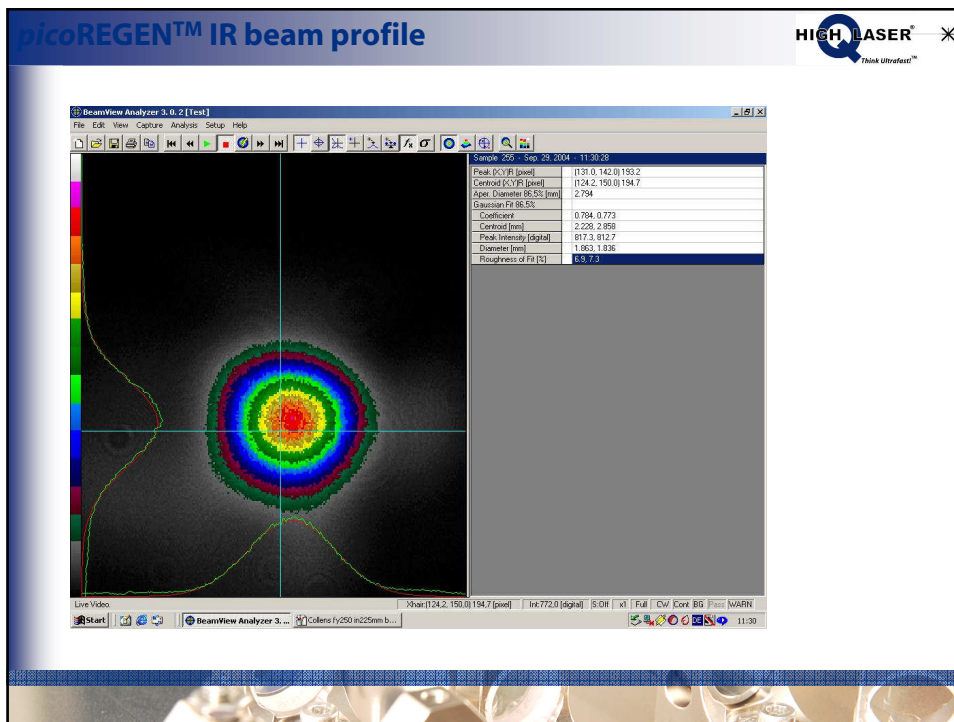


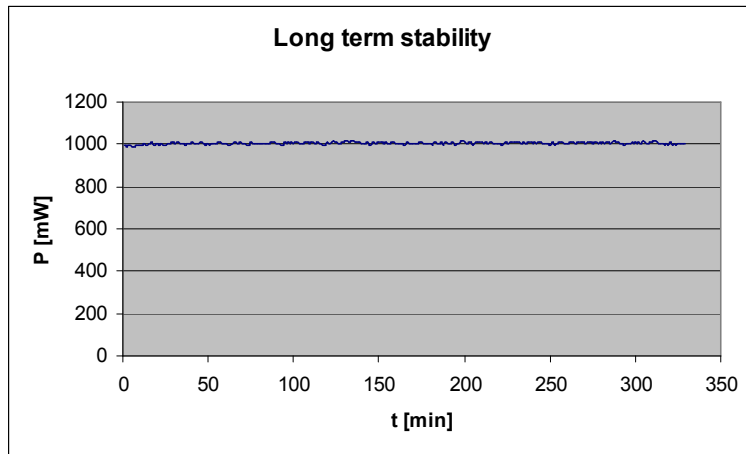
- FEA optimized industrial mirror mounts
- Access to end mirror and Pockels cell
- Improved laser crystal mount
- Double sided diode pumping

REGEN module top view (real 3D)



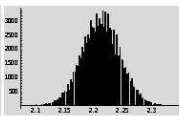
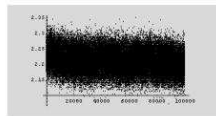
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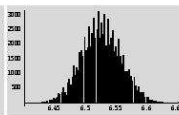
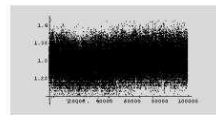
**532 nm, Power = 1000 mW, 2 kHz; RMS = 0,54%;
measured over 350 min = 5,8 h**

Pulse-to-Pulse stability in IR, SHG, THG, over 100000 shots



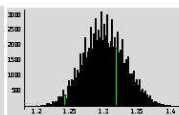
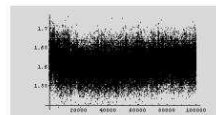
output @ 1047 nm
 $\sigma / \langle N \rangle \cong 0.0038$

IR: $\sigma < 0.4 \%$



output @ 523 nm
 $\sigma / \langle N \rangle \cong 0.0046$

SHG: $\sigma < 0.5 \%$




output @ 349 nm
 $\sigma / \langle N \rangle \cong 0.0094$

THG: $\sigma < 1 \%$


**Pulse Energy (a.u.)
vs. Pulse Number
(from 1 to 100000)**

histograms

picoREGEN™ Series **HIGH LASER**  Think Ultrafast™

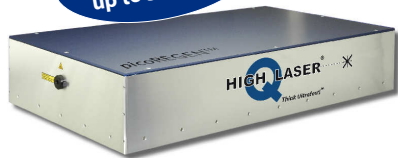
picoREGEN™ UC-INDUSTRIAL

NEW
30 W
Smallest footprint



picoREGEN™ SCIENCE

NEW
up to 3 mJ
up to 500 kHz



All-in-One Picosecond Regenerative Amplifiers

Different UC-models

UC-10000 HP 10 W s.p. - 500 kHz, 20 μ J
 UC-30000 HP 30 W s.p. - 500 kHz, 60 μ J
 → TTL Trigger
 → Nd:Vanadate

Different SCIENCE models

SC-527-1200 SLR 0 – 2(50) kHz, 1.2 mJ;
 SC-1053-3000 HE 0 – 2(50) kHz, 3.0 mJ
 SC-1064-2000 TTL 5 or 10 kHz, >0.3 mJ
 SC-1064-2000 HR 1 – 100(500) kHz, 0.3 mJ

High Q Laser - Product Groups **HIGH LASER**  Think Ultrafast™

TRAIN Serie: Diode pumped ultrafast solid state oscillators
 picoTRAIN™: 5 – 100 ps, 266 – 1342 nm, 8 – 1500 MHz, up to 25 W
 femtoTRAIN™: 50 – 400 fs, 800 – 1070 nm, 50 – 120 MHz, up to 5 W

NOVA Serie: Cavity-Dumped Mode-locked ultrafast oscillators
 femtoNOVA™: Up to 1 μ J, single pulse to 1 MHz TTL trigger
 picoNOVA™: Up to 1 μ J, single pulse to 1 MHz TTL trigger

REGEN Serie: All-in-one ultrafast regenerative Amplifier
 picoREGEN™: 8 – 18 ps, 1047 – 1064 nm, up to 500 kHz, up to 30 W, up to 3 mJ
 femtoREGEN™: 350 – 650 fs, 1030 – 1053 nm, up to 500 kHz, up to 8 W, up to 1 mJ

Custom Laser Systems - Examples



ps-Ti:Sapphire oscillators and amplifiers

High power oscillators up to 20 W

Regenerative fs/ps amplifiers with up to 500 kHz rep rate

Cavity dumped MHz-laser-system:

Up to 1 MHz / up to 1 μ J / ps- and fs- pulses

Burst-mode regenerative amplifier:

1.06 μ m / 1 kHz burst operation / 10 pulses per burst / 4 mJ per burst / 10 ps pulses

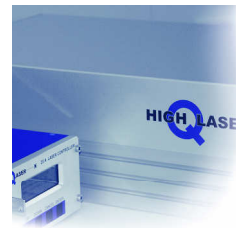
946 nm / 473 nm picosecond laser

1.34- μ m picosecond laser:

1.34 μ m / 3 W / 15 ps pulses

ps-OPO (for CARS-microscopy):

SHG: 0.7 – 1 μ m; 1.5 W, 1.4 – 2.1 μ m (signal) / 2.15 μ m – 4.4 μ m; up to >2 W;



Add Ons & Options



SYNC Option

all-electrical repetition rate synchroniz.

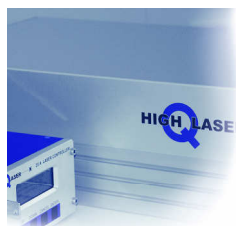
pulse jitter < 0.5 ps (RMS)

pulse repetition rate 50 – 400 MHz



Electro-optical pulse selection module „Pulse Picker“

Cavity Dumping Module: 1 μ J @ 1 MHz for TRAIN series



Long Pulse Option

SHG, THG, FHG

Customized replate: down to 8 MHz, up to 1500 MHz, variable Repetition Rate

High Q Laser – company overview



- **Founded 1999**, privately owned and financed
- Specialized in development, manufacturing and distribution of ultra short diode pumped solid state laser (DPSSL) systems
- **Headquarter** at Hohenems (by lake Constance)/Austria
- **International strong Team** of about ~45 specialists and academics
- More than 300 installed lasers Systems worldwide
- **Class 100 clean room** manufacturing
- More than 60 scientific **publications**
- **Main Markets** are Research , Medical, Imaging, Nanoprocessing, Semiconductor
- **Subsidiary** (100%) for Sales and Service in **Masachusetts/USA**; Worldwide distribution and service network

Strong Points and Expertise



- **Strong Team**
- **Compact Design**
- **Modular Concept**
- **Innovative R&D**
- **OEM Experience**

Thank you ...



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Measuring Tools



Optical Spectrum



Frequency Spectrum



Time Behavior



Beam Profile



Autocorrelation



Power Meter

