Ultraefficient on-chip supercontinuum generation: Bringing high quality & portable sensing devices within reach

Haider Zia , CTO & Founder

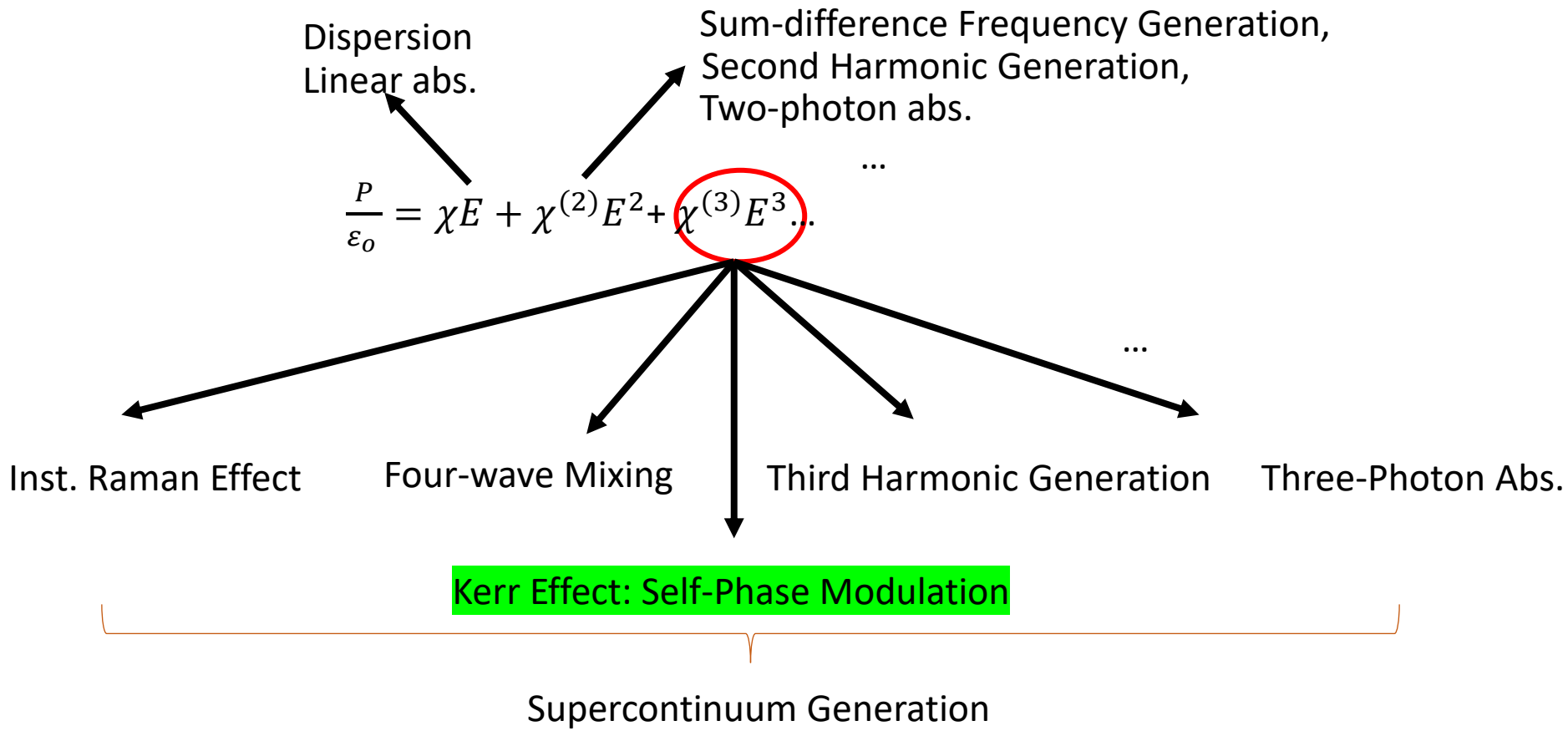
EPIC Technology Meeting @Ligentec

SuperLight Photonics BV ©

- Spin-out of Twente University, Enschede, The Netherlands
  - Founded in Nov-2022 by Dr Haider Zia
    - First funding round closed in Sep-2023
  - Located downtown Enschede, NL
  - Focusing on advanced PIC-based light sources

SUPERCONTINUUM GENERATION

- Wide and continuous spectrum from narrow seed source using nonlinear effects. Born from Nonlinear polarization, e.g scalar form:



KERR EFFECT : SELF PHASE MODULATION

- Scales with peak intensity -> High confinement in waveguides
- Refractive index is time dependent function of pulse intensity
- Adds time dependent phase to the pulse envelope function
  - This is what generates the spectral broadening
- Adds the following term to the nonlinear propagation

$$\frac{dA}{dZ} = -\frac{\alpha(t)}{2} \otimes A + \sum_{k=2}^{\infty} \frac{i^{k+1}}{(k)!} \frac{\partial^k}{\partial^k \tau} A + i\gamma\left(1 + i\tau_s \frac{\partial}{\partial \tau}\right) A \int R(T)|A(\tau - T)|^2 dT$$

Lin.loss response fnct — dispersion — Inst. SPM, inst. Raman, delayed Raman

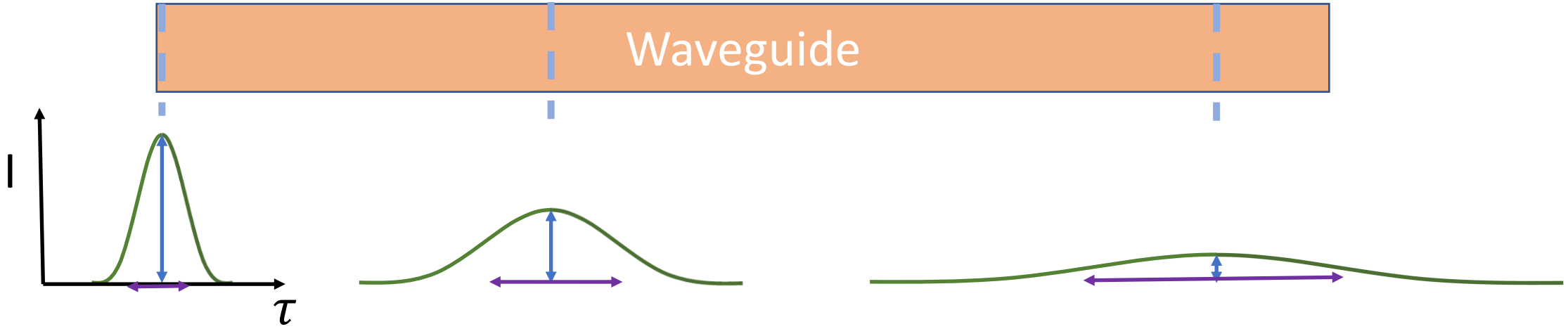
*A is pulse envelope, γ is waveguide nonlinear coefficient, τ_s is higher order SPM coefficient

CONVENTIONAL TECHNOLOGICAL RESTRICTIONS

Mechanism of Spectral Stagnation

Normal Dispersion Case: $\beta_2 > 0$

Additive spectral phase enhances temporal broadening



- Peak intensity reduction
- Increased pulse duration

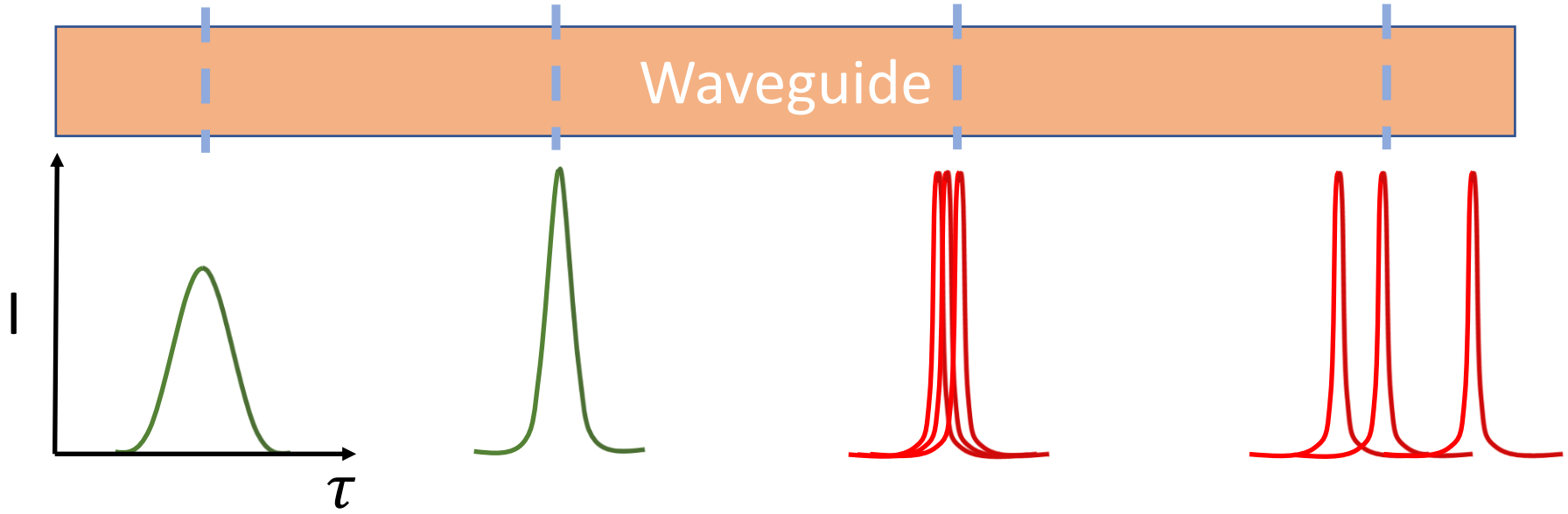
Bandwidth asymptotically approaches a constant (saturates)

β_2 : Group Velocity Dispersion Parameter

Mechanism of Spectral Stagnation

Anomalous Dispersion Case: $\beta_2 < 0$

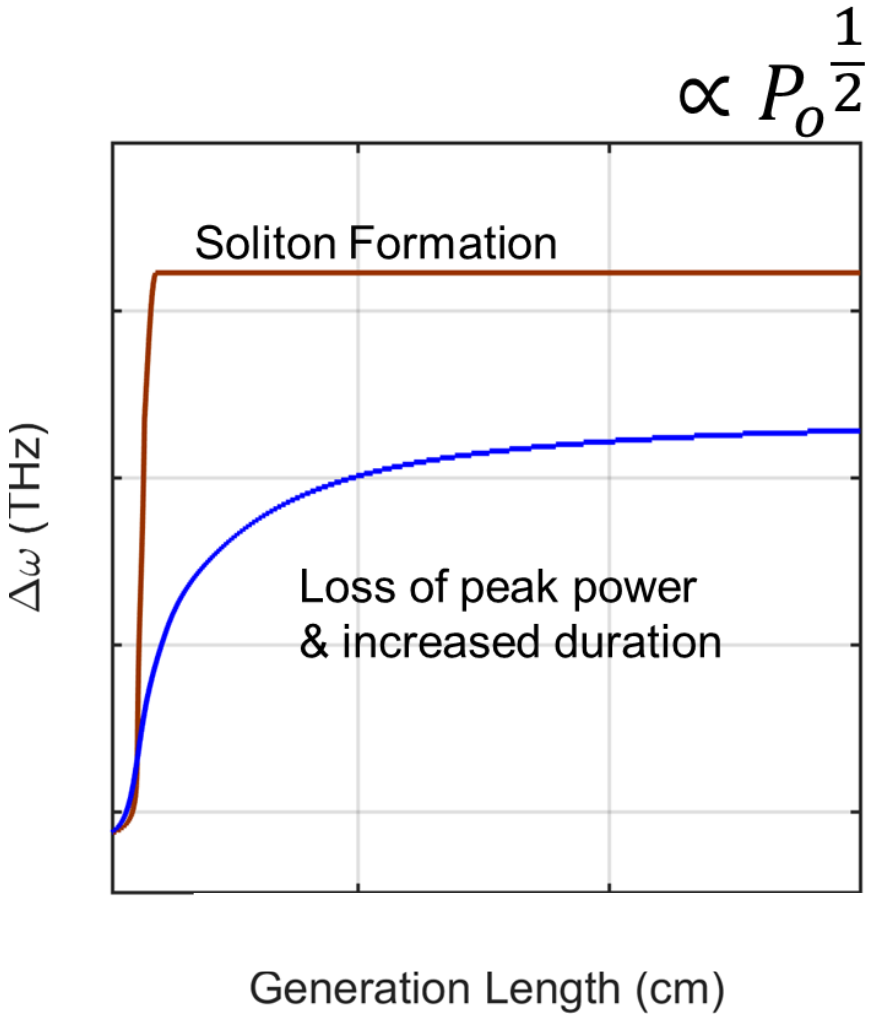
Additive spectral phase enhances pulse compression to solitons

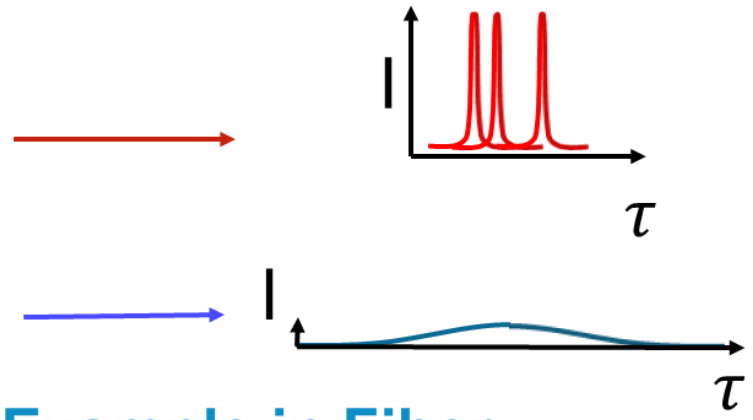


- At first reduces its duration, raising peak intensity
- Becomes solitons centered at different frequencies
- Solitons are stationary solutions that have invariant spectral profiles

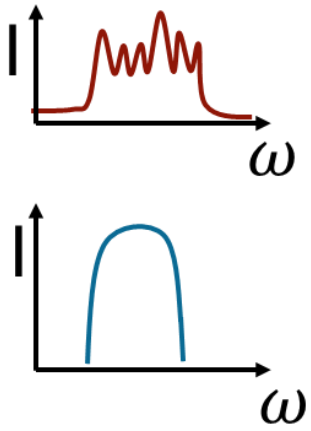
β_2 : Group Velocity Dispersion Parameter

QUANTITATIVE VIEW OF SPECT. SATURATION





Soliton fission : modulated spectrum due to spectr. interference and modulation inst.

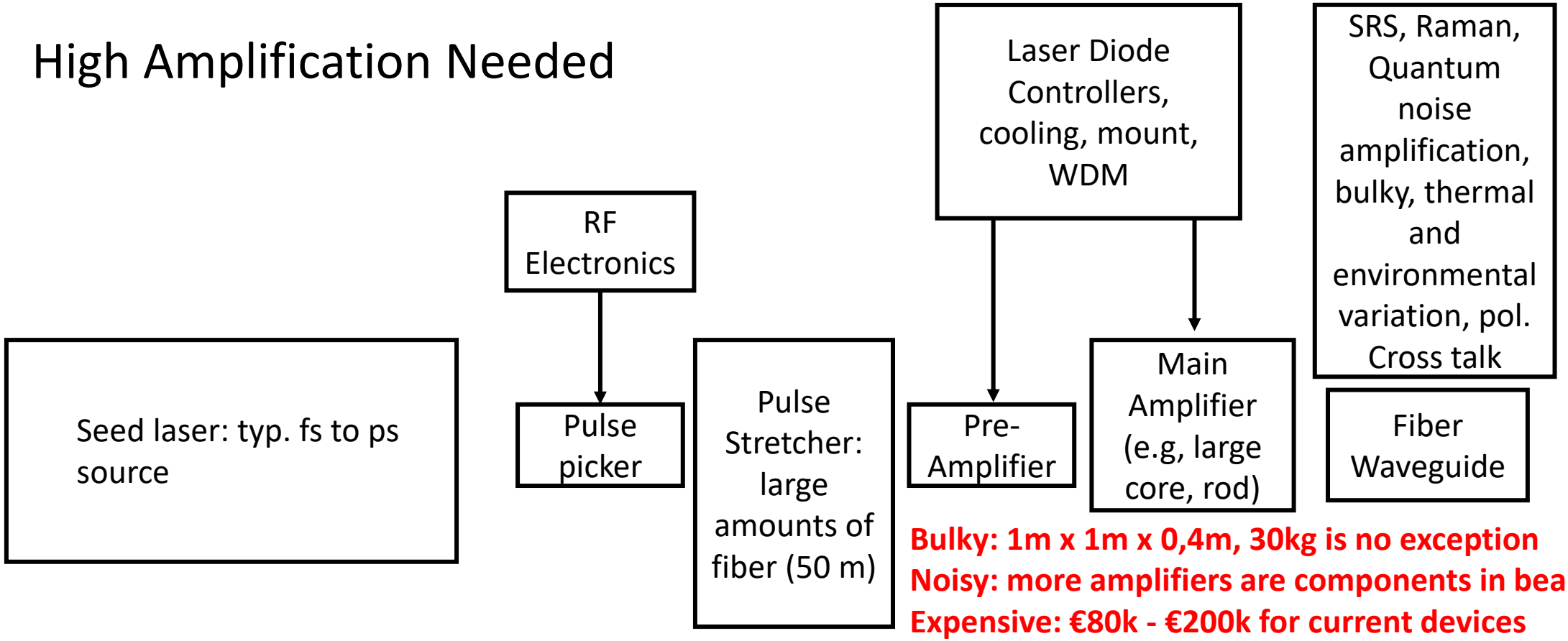


Example in Fiber

- Both dispersion types have spectral stagnation
- Anomalous dispersion spectrum:
  - Greater bandwidth due to initial temporal compression
  - But more spectral interference
- Both saturation values scale weakly with input power

LEGACY GENERAL SCG LASER LAYOUT

High Amplification Needed



Bulky: 1m x 1m x 0,4m, 30kg is no exception
Noisy: more amplifiers are components in beam path
Expensive: €80k - €200k for current devices
Lots of components, delicate
Spectral quality is low: *Other colors in the spectrum are at powers 1000's of times lower than the original monochromatic seed laser*

THE SLP ADVANTAGE

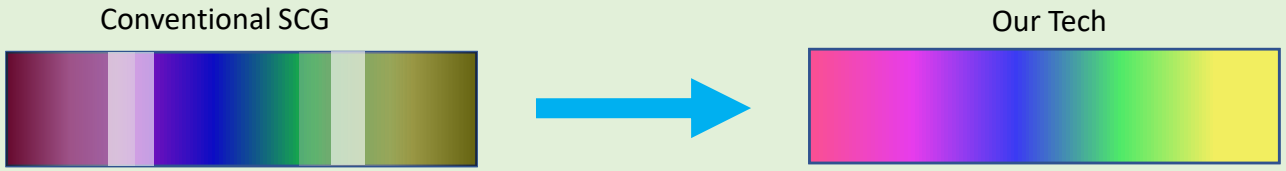
Wideband – SCG

Portable

SLP TECHNOLOGY

Chip (and fiber)-based Supercontinuum Generation:

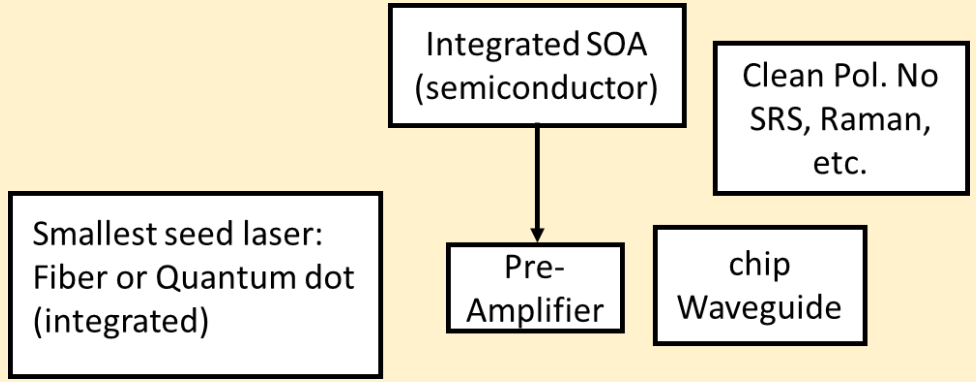
- Power reduction by factors up to thousands using Sign alternating dispersion (PAD)
- World record high broad spectrum and lowest noise
- All colors have similar powers in the bandwidth



This solves the challenges:

- Small and portable
- Scalable
- Easy to integrate in devices out of big controlled environments
- In SIN or any photonics platform

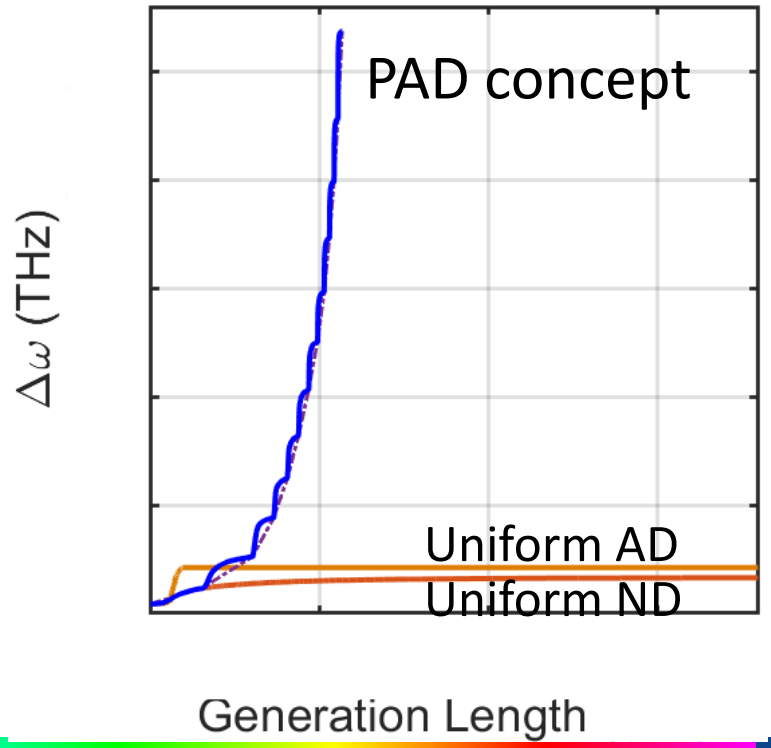
Our integrated SCG bare chip In action

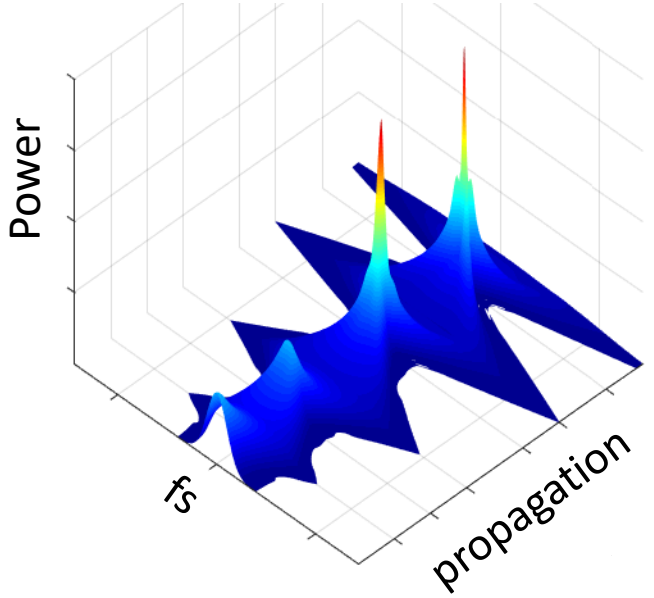


Best and first chip-based supercontinuum technology at record-low powers

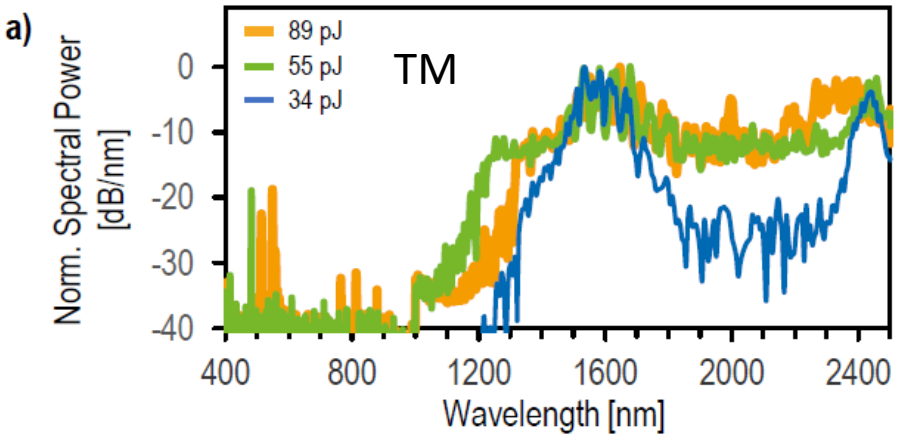
SIGN-ALTERNATING DISPERSION SCG

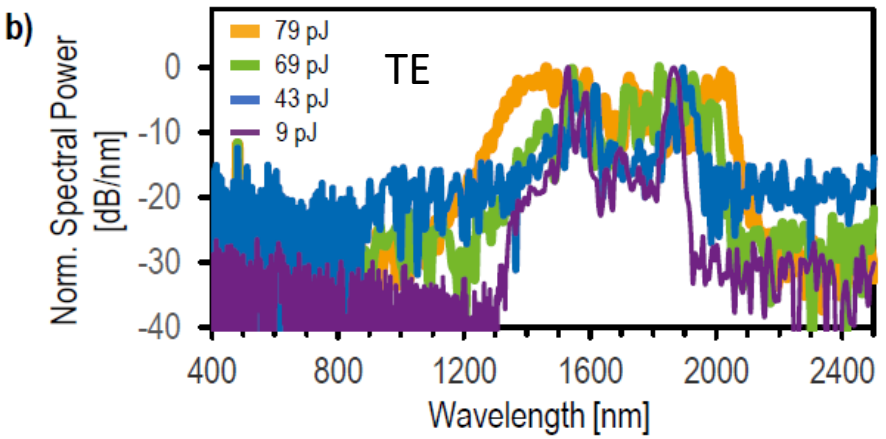
- Alternating the sign of dispersion repeatedly :
  - Counters stagnation from normal dispersion SCG dynamics due to pulse broad., peak power loss
  - Counters stagnation from anomalous dispersion SCG by disrupting Soliton form.
- Pulse nonlinear temporal compression with high quality



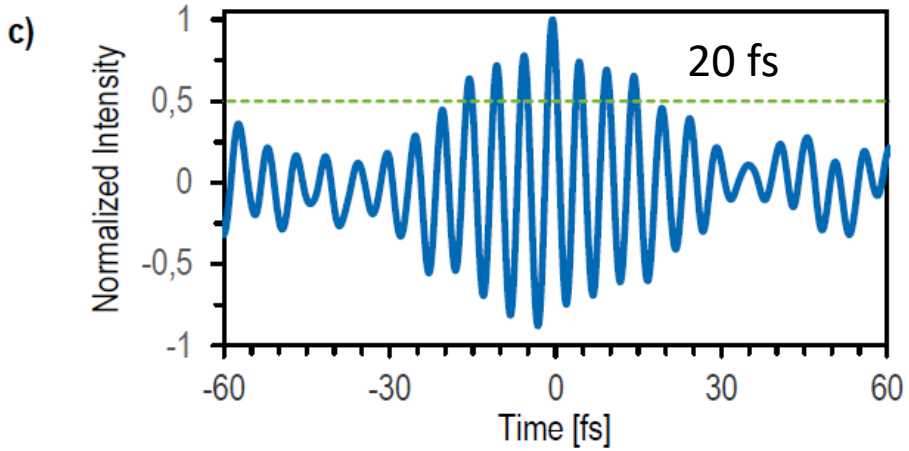


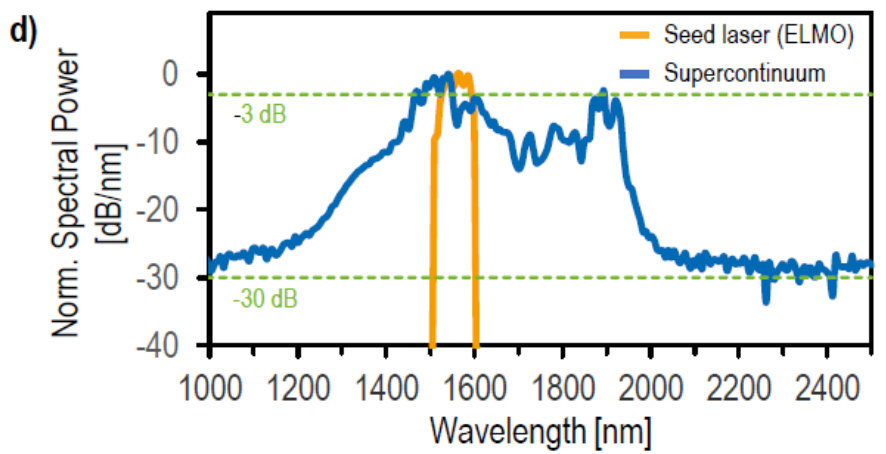
EXPERIMENTAL RESULTS





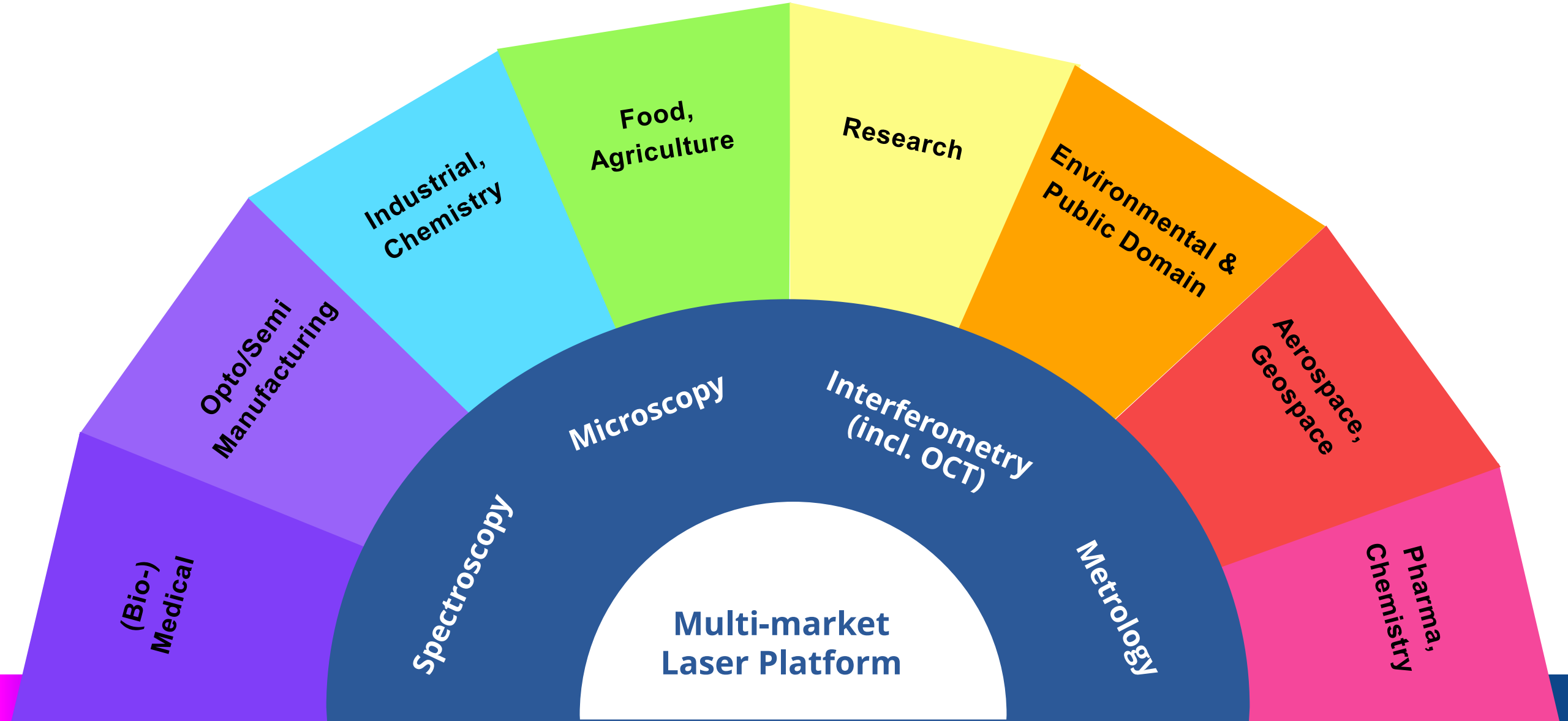
- Sign-alternating waveguide in PIC SiN platform
- Structures for TE and TM polarization





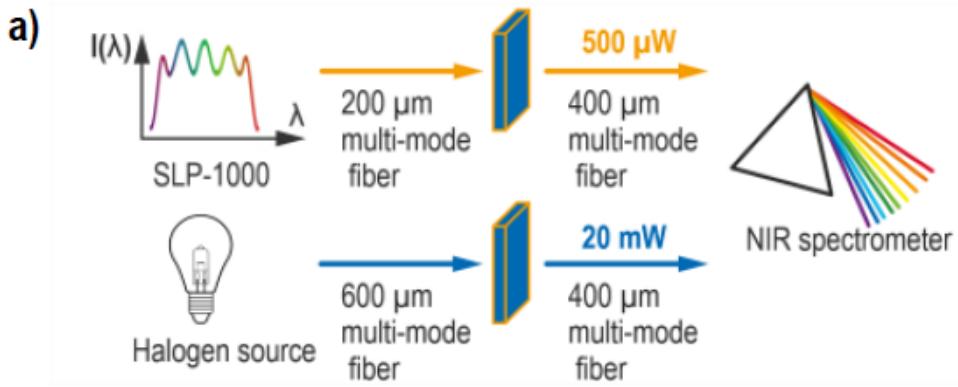
- Robust with differing input pulse conditions (200 fs to 100 fs)

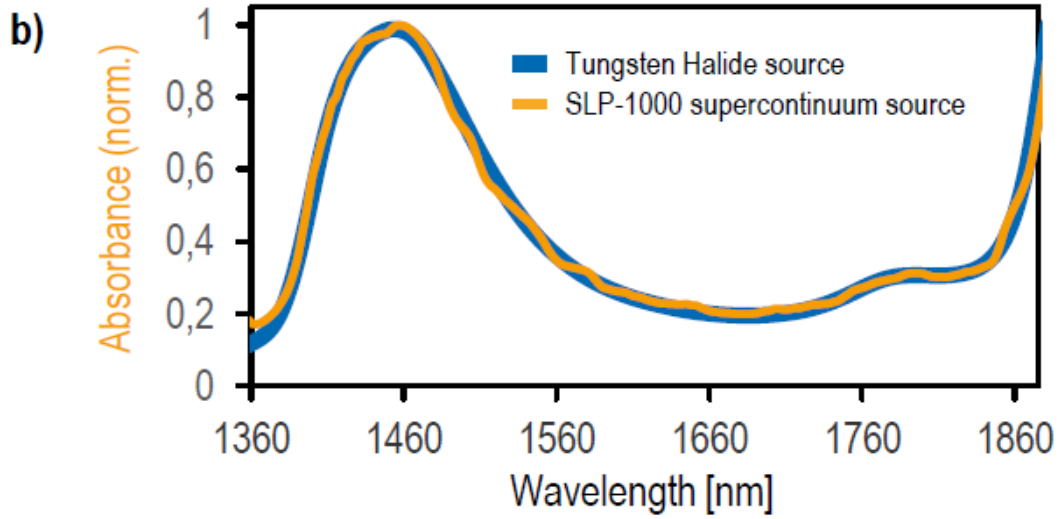
MOVING FRONTIERS IN APPLICATIONS



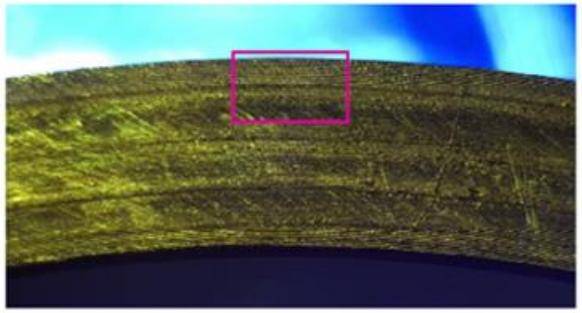
LASER ABSORPTION SPECTROSCOPY

- Comparing SLP sign-alternating dispersion SCG laser (SLP-1000) with Halogen lamp for spectroscopy
- 500 uW at detector versus 20 mW (Halogen)
- Low noise, coherence greatly wins ➡ same performance at approx. 40 times less power
- This means 40X more sensitive or 40X less integration time!
- Ideal for gas spectroscopy or materials with low absorption cross sections
- Transverse scanning functionality and spatially resolved spectroscopy -> Hyperspectral imaging and OCT
- High brightness for scanning spectroscopy functionality

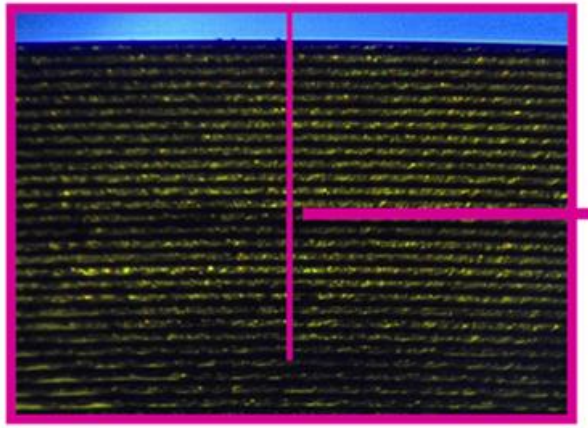




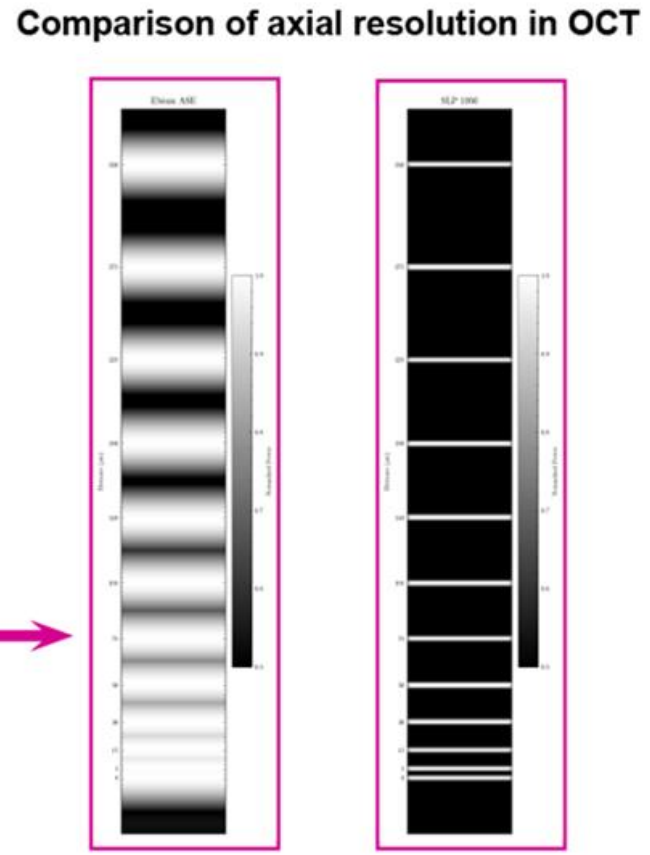
OCT WHITEPAPER



Microscope image tape



Microscope image - tape sample detail



Comparison of axial resolution in OCT using FWHM measurements of stepped mirrors positions.

Left ASE source shows broad, overlapping lines at finer steps.

Right SLP-1050 supercontinuum source results in sharper lines, demonstrating significantly improved resolution.

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- Z-resolution for OCT yields z-resolution of <770 nm. Ideal for semiconductor surface scanning

TEAM

Total Team

- **11 FTE - 12 employees**
- **Mgmt + Adm: 6 FTE**
- **Engineers: 5 FTE**
- **Level: 3 PhD, 7 Master**

Haider Zia
Founder & CTO

- Over 10 years optics & photonics research experience
- PhD at Max Planck Institute and MIT (2015)
- Postdoc & Senior researcher at Twente University (2022)
- Inventor of patented extremely power efficient wide-bandwidth chip integrated lasers
- NWO Demonstrator Grant Award top-place recipient

Elly Schietse
CMO

- 30 years scale-up experience
- Long career in technology start-ups & scale-ups
- Track record marketing, marcom & PR
- International HR management
- Implemented & certified ISO 9001, 27001 & 14001
- Lean organizational design
- Experience in high-tech, ICT, SaaS, ERP, IoT, semiconductor, Industry 4.0

Bradley Snyder
COO

- Over 20 years multi-disciplinary experience
- PhD at Tyndall National Institute, Ireland (2013)
- Track record in photonics packaging manufacturing
- Long experience in R&D, silicon photonics, optical design
- Spearheaded every stage of photonics design, layout, wafer-scale fabrication and test

Cees Links
CEO

- Over 35 years industry experience
- Alumnus Twente University (1982)
- GM/VP (NCR Computers, AT&T, Lucent Technologies, Qorvo)
- Established Wi-Fi as worldwide standard
- Founder/CEO (GreenPeak Technologies) with successful exit to Qorvo (2016)
- RF-semiconductor industry, wireless data communication, ultra-low power

Jeroen Biesterbos
CCO

- Over 10 years commercial experience
- ams-OSRAM and Sensata Technologies
- Track record of success in Business Development, Product Marketing, Product Management
- LiDAR semiconductor lasers and ecosystem
- Automotive & industrial background

Paul de Wit
CFO

- Over 30 years experience in Finance
- Master in Finance & Control
- Experience in both corporates & start-up/ scale-up international environments
- Track record in equity rounds, exits, non-dilutive funding, subsidies and working capital funding at private equity backed semiconductor companies
- Experience with managing HR, real estate and office IT

Thank you!

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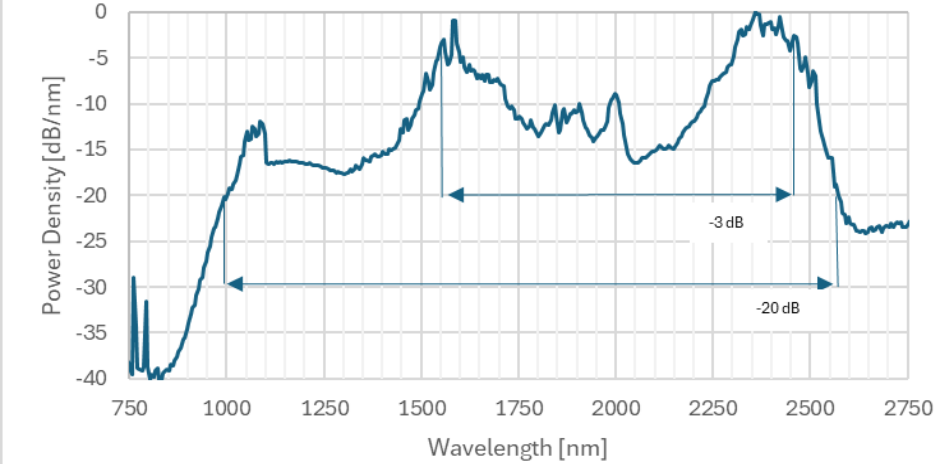
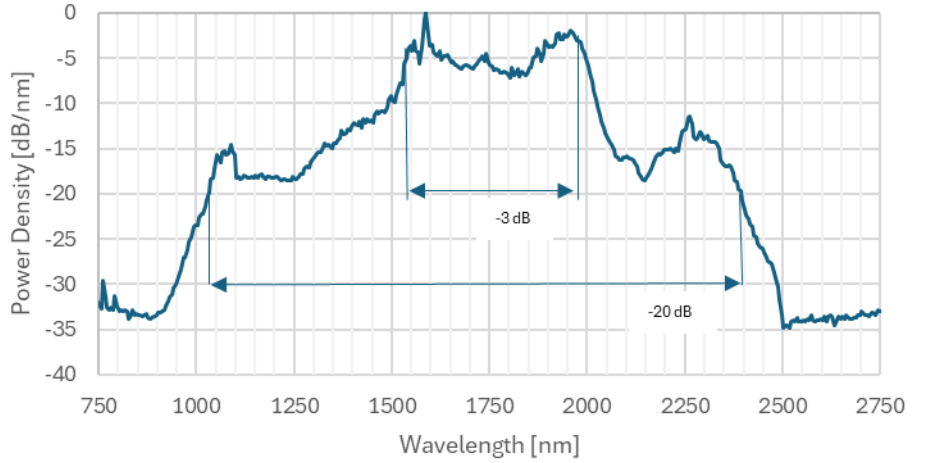
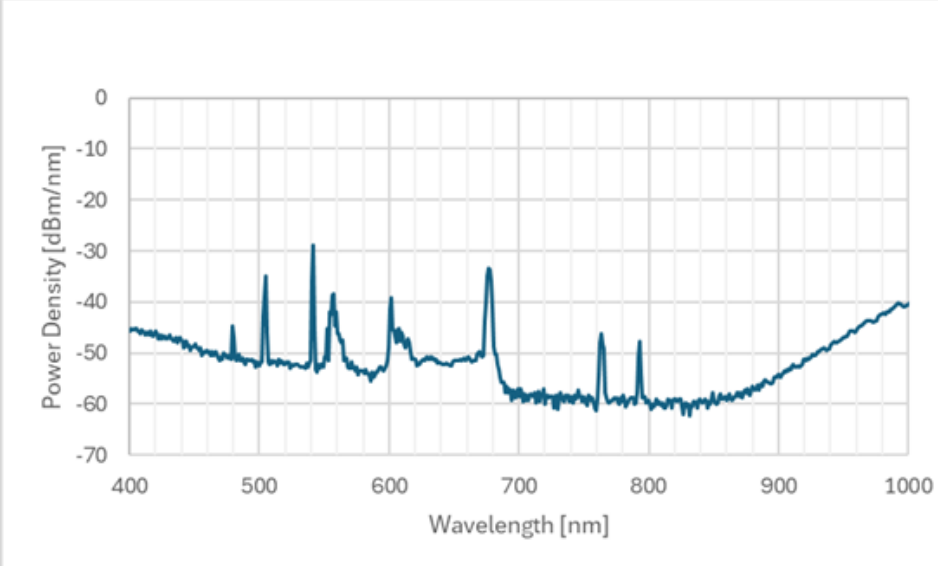
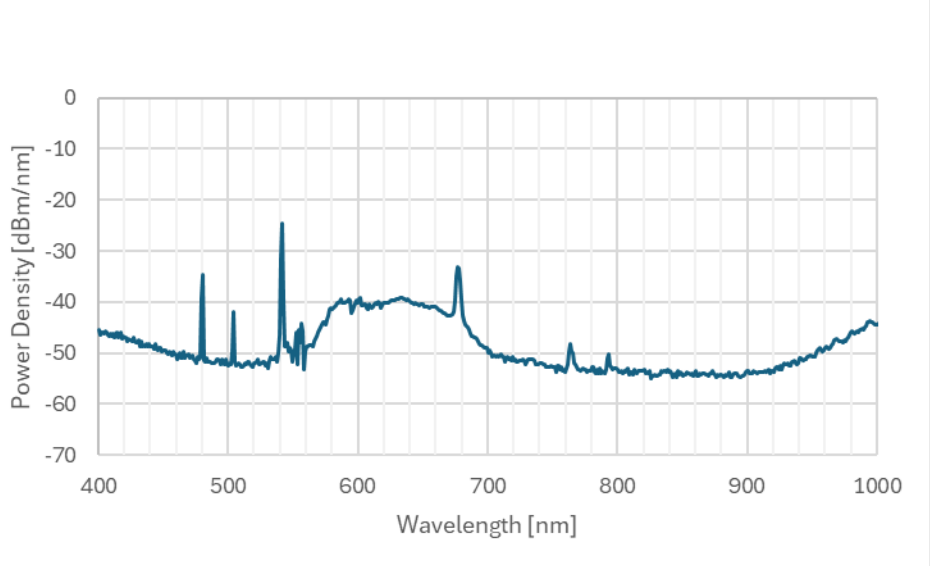
TM

TE

SWIR

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