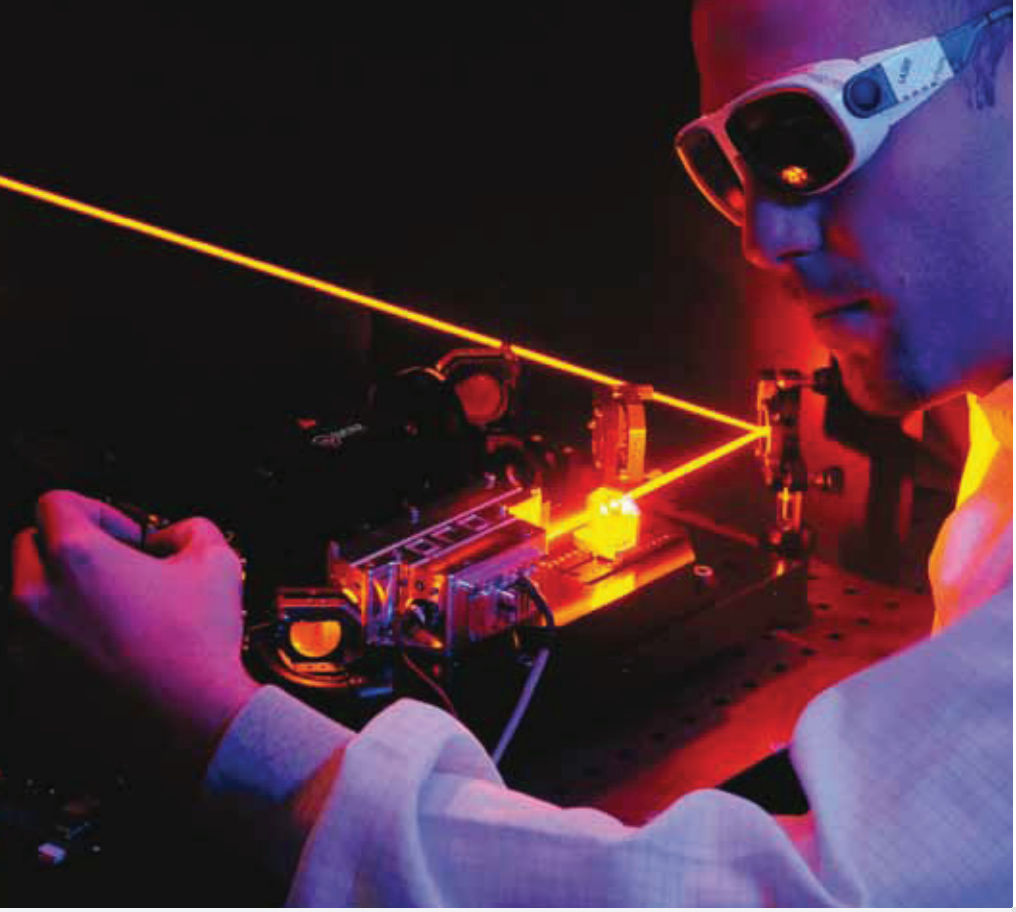


Frequency Converted Lasers

Closing the spectral gaps

Despite the success story of semiconductor lasers, there are still some spectral "gaps" that cannot be directly accessed with diode technology. Nonlinear frequency conversion techniques close these gaps by generating laser radiation in the UV, blue, green, yellow and red spectral range. TOPTICA manufactures state-of-the-art systems based on second harmonic generation (SHG) and fourth harmonic generation (FHG). Customized systems for sum and difference frequency generation (SFG, DFG) are available upon request.

TOPTICA's frequency converted lasers are available in the spectral range between 205 nm and 640 nm, with only few spectral gaps. Combining know-how in diode laser technology and extensive experience in customized frequency conversion, highest output power levels and best performance are achieved. For customers that already possess a single frequency cw laser which is supposed to be frequency-doubled, TOPTICA also offers a stand-alone second harmonic generator.

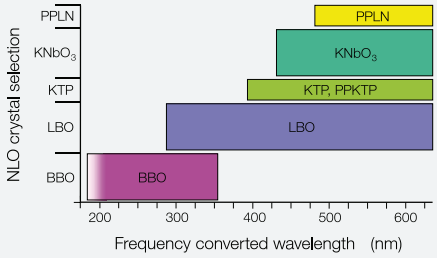
Second Harmonic Generation (SHG)

The most common frequency conversion approach is the exploitation of second harmonic generation. In the wave picture, the fundamental electromagnetic wave (frequency ω_1) drives the polarization of a non-linear optic (NLO) crystal. This polarization oscillates not only at the fundamental frequency but, due to the nonlinearity, also at the "second harmonic" frequency $\omega_2 = 2\ \omega_1$. This in turn leads to the generation of coherent radiation at the frequency ω_2. In the photon picture, two photons of the fundamental laser (wavelength λ_1, frequency ω_1) are combined within an NLO crystal into one photon of twice the original frequency and half the original wavelength ($\omega_2 = 2\ \omega_1$, $\lambda_2 = 0.5\ \lambda_1$). The efficiency of this process increases with the fundamental power, the non-linearity of the NLO crystal and the proper fulfillment of the phase matching condition, i.e. the refractive index of the fundamental and the frequency-doubled laser light have to be equal within the NLO crystal.

TOPTICA's SHG systems

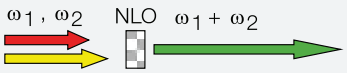
Our SHG systems use a compact and rugged bow-tie resonator design with optimized mirror coatings to resonantly enhance the fundamental laser power. The resonator length is actively stabilized to the fundamental wavelength by means of the Pound-Drever-Hall method (page 49). This allows for highly stable locking of the resonator length, and thus reliably enhances the intra-resonator power of the fundamental laser. Optionally, a "Double-piezo lock" can be integrated to realize a locking bandwidth > 10 kHz and a large scan range at the same time.

A specially selected, anti-reflection coated NLO crystal is placed inside the resonator and actively temperature controlled. The phase matching condition is fulfilled either by temperature tuning or angle tuning, depending on the crystal type and operating wavelength. TOPTICA's specialty: Depending on requested laser power, wavelength and tunability, different types of NLO crystals are used. A selection of important crystals is shown above.

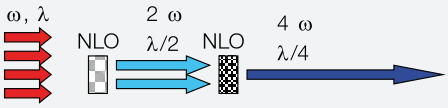


TOPTICA's selection of non-linear crystals and their frequency converted wavelength range. All crystals have premium quality antireflection coatings. TOPTICA will choose the best crystal for your specific application.

Principle of Second Harmonic Generation (SHG)



Principle of Sum Frequency Generation (SFG)



Principle of Fourth Harmonic Generation (FHG)

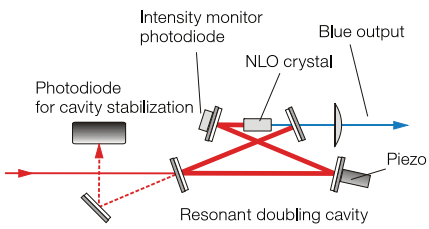
Principle of Difference Frequency Generation (DFG)

pro philosophy in frequency converted systems

Ease of use, best performance and highest stability are key characteristics of any of TOPTICA's "pro" lasers. In TOPTICA's frequency-converted systems, the laser head is machined from a solid metal block for enhanced robustness against vibrations, acoustic noise and temperature. Integrated flexure based mirror mounts provide an unmatched long-term stability. The "bow-tie" resonator SHG pro comes in a closed design with entrance and exit windows, and can be adjusted without opening the lid. The SHG wavelength is tuned by altering the fundamental laser color. Mode-hop free tuning of several 10 GHz is realized by scanning the fundamental laser while the SHG resonator follows automatically. This tuning is fully adjustment-free and can be performed via an analog input or even under digital control. Coarse tuning over several nm is achieved by manually changing the wavelength of the fundamental laser. Only if phase matching has to be optimized, becomes a readjustment of the SHG resonator necessary.

Diode laser advantages

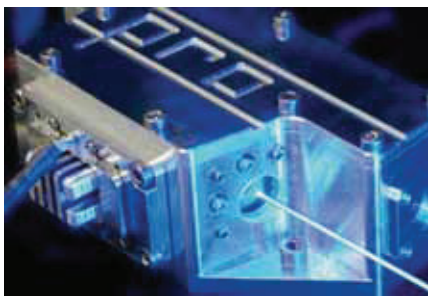
Compared to other frequency-converted laser systems (e.g. optically pumped dye lasers with subsequent doubling stage, or frequency-doubled Ti:Sa lasers), advantages of semiconductor configurations are that neither an external pump laser nor water cooling are required. The systems are most compact in size, extremely reliable, conveniently operated, and running costs can be kept low. Thanks to TOPTICA's pro design, adjustments can be executed even by the non-specialist.



Sketch of Second Harmonic Generator

Standard systems and customized solutions

On the next pages, different "standard" system configurations are presented. Together with you, TOPTICA's experts will identify the best version and customize it according to your requirements. If none of the standard systems matches your needs, we will investigate options like sum frequency generation, described on the "Inventive Frequency Converted Solutions" page 41. Last not least, the TOPSeller systems are preconfigured lasers for applications served many times a year.



Air-sealed SHG cavity

SHG pro

Stand-alone Second Harmonic Generator

SHG pro — flexible stand-alone Second Harmonic Generator.

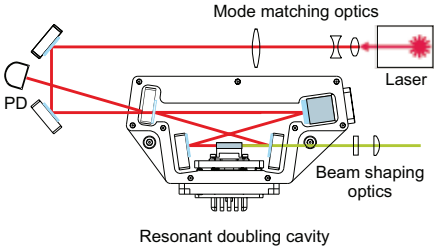
Professional unit for frequency doubling of cw lasers

The stand-alone Second Harmonic Generator SHG pro is the device of choice if existing cw lasers are to be frequency-doubled. The SHG pro package comprises mode matching optics for the external laser, ultra-stable beam steering mirrors, digital locking electronics with automatic relocking for Pound-Drever-Hall stabilization of the resonator length, the bow-tie resonator in pro design, and beam shaping optics for the frequency-doubled light. The temperature controlled NLO crystal and the mirror coating are specially selected according to customer demands.

Two integrated piezo-electric actuators for the stabilization of the resonator length are another specialty of the SHG pro. One actuator serves for high frequency response while the other one is used for large amplitude regulation. TOPTICA offers competent technical support to adapt the SHG pro to many varieties of existing laser systems.

Key features

- Compact, stand-alone bow-tie cavity with highest mechanical and thermal stability
- Frequency doubling of single-frequency lasers, e.g. Ti:Sapphire, Cr:LiSaF, dye lasers, gas lasers, DPSS, diode and fiber lasers
- Highest cw conversion rates
- Nearly diffraction-limited beam profile
- Fiber coupling optional



Sketch of SHG pro, stand-alone second harmonic generator.

Specifications SHG pro		
Wavelength range*	410 nm - 1600 nm	205 nm - 800 nm
Optical conversion efficiency**		
410 nm - 500 nm	205 nm - 250 nm	5 - 10 %
500 nm - 700 nm	250 nm - 350 nm	12 - 20 %
700 nm - 900 nm	350 nm - 450 nm	20 %
900 nm - 1600 nm	450 nm - 800 nm	40 - 60 %
General characteristics		
Beam quality	nearly diffraction limited, single-mode fiber coupling efficiency > 60 % @ 400 nm	
Beam diameter	1 - 2 mm	
Beam height	50 mm	
Continuous scan range	> 60 GHz @ 400 nm output	
Polarization	Linear	
Polarization ratio	> 1000:1	
Residual infrared	Typ. < 1 % (< 0.1 % with extra filter)	
Locking scheme***	Pound-Drever-Hall with automatic relock, double piezo lock optional	
Output power noise	Typ. < 3 % (depending on laboratory conditions & fundamental laser)	
Operating temperature	15 - 30°C	
Warm-up time	Typ. < 5 minutes (depends on final crystal temperature)	
Operating voltage	100 - 120 V / 220 - 240 V AC, 50 - 60 Hz (auto detect)	
Power consumption	< 50 W	
Dimensions (L x W x H)	400 x 216 x 90 mm^3 (head) and 12“ rack	
Approx. weight	8 kg (head) + 10 kg (control electronics)	

*Total wavelength range coverage requires several NLO crystals and mirrors, other wavelengths upon request. **Assuming 1 Watt single-frequency (< 1 MHz linewidth) cw laser input, max. output power at wavelengths < 300 nm may be limited by crystal lifetime. ***May require additional EOM (purchase and integration from TOPTICA recommended)

DL-SHG pro

Frequency Doubled Diode Lasers

Medium power, tunable UV, blue, green, yellow or orange light

The DL-SHG pro system is a medium power solution with the main applications being spectroscopy of atoms, ions or molecules, laser cooling of ions, photo ionization and interferometry. Thanks to the pro design, it combines best performance at moderate initial and operating cost.

The DL-SHG pro package comprises a solid laser head and a double stage 19" DC 110 electronics rack, including all modules needed to operate the fundamental laser, to stabilize the SHG resonator with respect to the laser wavelength, and to thermally control the NLO crystal. The electronics rack can be equipped with additional modules to stabilize the frequency of the fundamental laser or to further narrow its linewidth.

The laser head features a grating stabilized diode laser in DL pro design and the enhancement cavity SHG pro. High performance optical isolators (60 – 90 dB) prevent unwanted feedback into the diode laser. The NLO crystal and the mirror coatings are carefully selected. Newly developed beam steering mirror mounts guarantee best short and long term stability of the output power. A probe beam output of the fundamental laser is also provided.

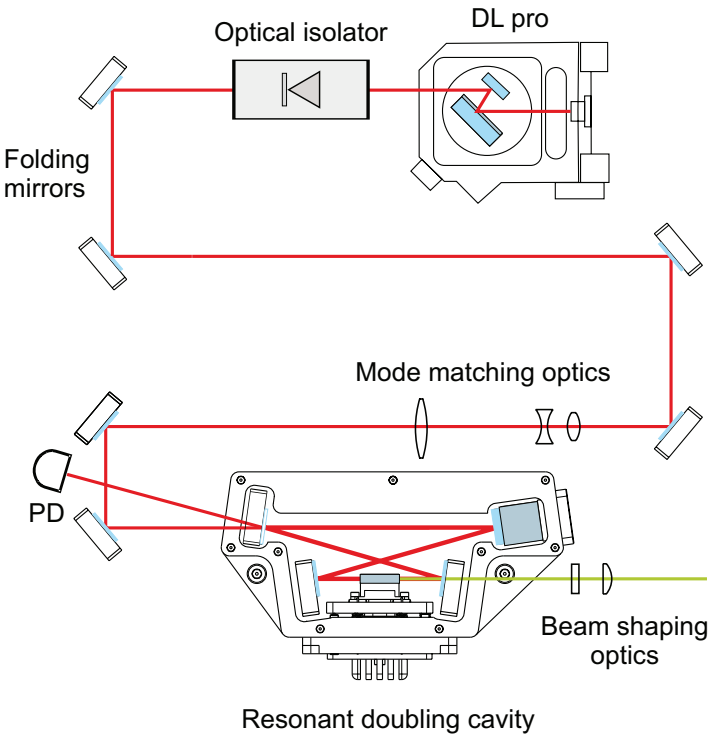
Each individual DL-SHG pro system is a customized laser. While stability and ease of use are common for all systems, other parameters like output power, coarse and fine tuning depend on the target wavelength and on the specific design. Typical values are: wavelength within 390 nm to 640 nm, output power from 1 mW to 40 mW, coarse tuning 2 nm to 10 nm, and mode hop free fine tuning 10 GHz to 30 GHz. Other specifications are listed on page 43, table “Specifications Frequency Converted Lasers”.

A high power upgrade of the DL-SHG pro can be undertaken at a later stage if an appropriate amplifier source is available.

DL-SHG pro — medium power cw, single frequency laser source.

Key features

- UV, blue, green, yellow or orange wavelengths: 390 nm – 640 nm
- Up to 40 mW output power
- Tunable single-frequency emission, typ. linewidth < 500 kHz
- Probe beam output of fundamental laser
- High power upgrade possible (depending on amplifier availability)
- Fiber coupling of probe beam / SHG output optional



Sketch of DL-SHG pro system: medium power solution at a variety of wavelengths from UV to orange.

TA-SHG pro

Frequency Doubled High Power Diode Lasers

TA-SHG pro—high power, cw, tunable UV, blue or green laser source.

Key features

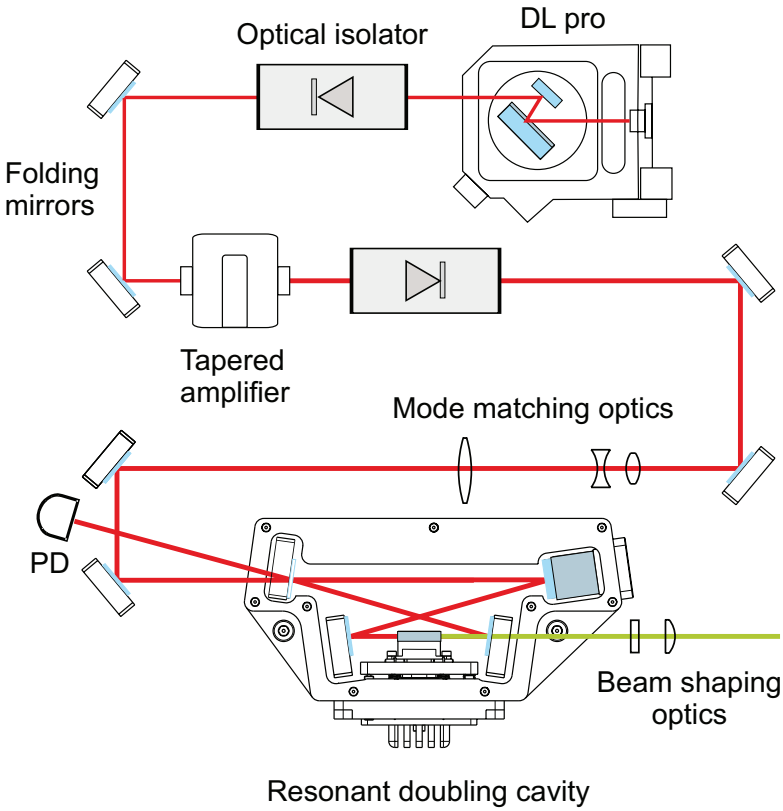
- UV, blue, green laser radiation: 323 .. 540 nm (with only few gaps)
- Up to 400 mW output power
- Tunable single-frequency emission, typ. linewidth < 500 kHz
- Probe beam output of fundamental laser
- Fiber coupling of probe beam / SHG output optional
- Active output power stabilization optional

High power, tunable UV, blue or green laser light

Many applications require tunable high-power laser radiation at specific wavelengths ranging from the UV to the green spectrum. Examples are laser cooling of atoms and ions, plasma spectroscopy or holography. The TA-SHG pro is not only the system of choice for these applications, but also serves as a replacement for HeCd or Argon ion lasers, especially if single-frequency operation and / or tunability are required.

From a conceptual point of view, the TA-SHG pro system is very similar to the DL-SHG pro laser. The main difference between the two is that in the TA-SHG pro system, the master laser is boosted in power by a tapered amplifier (TA pro), and once again optically isolated before it is coupled into the SHG pro resonator. Carefully selected optics and NLO crystals as well as an initial setup in a clean room environment then allow for significantly higher output powers, even under standard laboratory conditions. All other premium characteristics of the DL-SHG pro are maintained in the TA-SHG pro. Ultra-low noise sensitivity, best long-term stability of the laser frequency and output power, as well as ease of use are just a few of them. In fact, one can use the DL-SHG / TA-SHG pro lasers in a very similar way as “basic” grating stabilized diode lasers.

The TA-SHG pro lasers are available within a wide wavelength range (currently available 323 .. 540 nm with only few spectral gaps). Being customized systems, TA-SHG pro characteristics might vary from solution to solution. Depending on the design wavelength, typical output powers range from 10 mW to 400 mW. Other parameters are shown in “Specifications Frequency Converted Lasers”, page 43. Challenge us with your requirements!



Schematic of the TA-SHG pro system: high power at common and exotic wavelengths.

DL-(R)FA-SHG pro

Frequency Doubled Fiber Amplified Diode Lasers

High power at exotic wavelengths
Strongly driven by customer demands, TOPTICA developed frequency doubled diode lasers incorporating Yb fiber amplifiers and Raman-shifted fiber amplifiers. The combination of advanced diode laser and fiber amplifier technology allows for power levels and wavelengths that cannot be achieved using diodes alone. Popular examples are: 2 W to 20 W at 589 nm for Sodium laser cooling and guide star applications, or 250 mW at 550–560 nm for laser cooling of Barium and Ytterbium. Other wavelengths from 520 nm to 640 nm are available upon request.

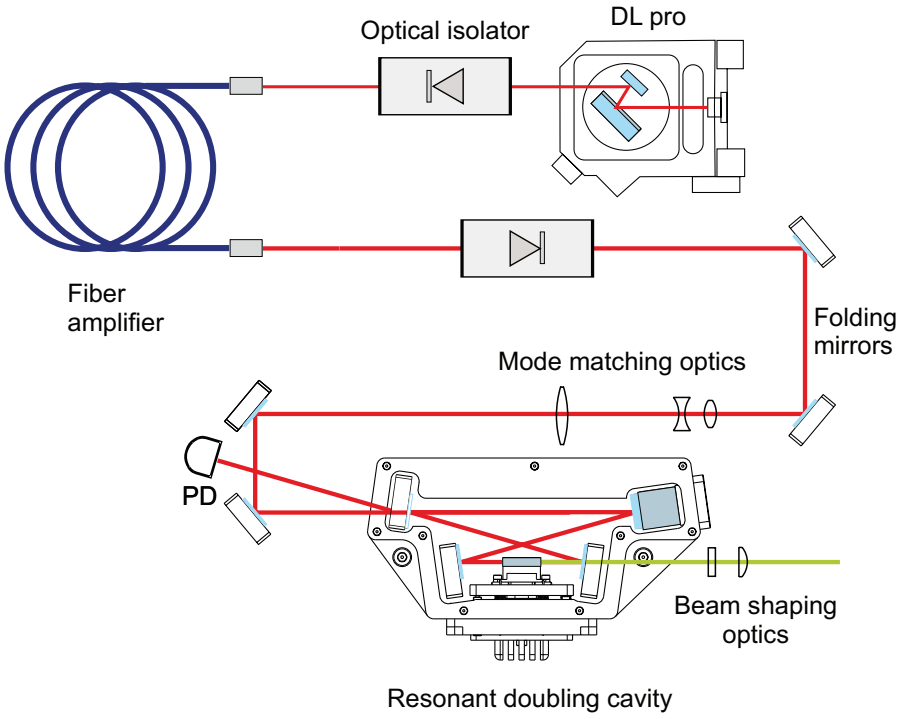
Diode laser meets fiber amplifier
The DL-FA-SHG pro and the DL-RFA-SHG pro systems use an external fiber amplifier (FA) or Raman fiber amplifier (RFA) operating in the near-IR range. The seed laser output is optically isolated, coupled into a SM/PM fiber using TOPTICA's patented FiberDock, and sent to the fiber amplifier. Both types of amplifiers, FA and RFA, are polarization maintaining, and boost the DL pro-type diode laser to power levels of 1 W to 30 W. The fiber amplifier output is coupled out of the fiber again and beam-steered into the SHG pro doubling stage. In short, the DL-(R)FA-SHG pro systems are DL-SHG pro systems with a two-fiber connection to an external (Raman) fiber amplifier.

Ease of use and outstanding stability for relaxed and reliable experiments
The frequency doubled (Raman) fiber amplified systems offer not only high power levels at "exotic" wavelengths but also a unique long-term stability. The systems can be tuned mode-hop free over typ. 10–20 GHz and coarsely over 1–6 nm, or be stabilized to an external reference. Narrow free-running linewidths and low frequency drift with temperature allow for easy operation on a day-to-day basis.

DL-FA-SHG pro and DL-RFA-SHG pro—high power, cw, tunable green or yellow laser.

Key features

- Available wavelengths 520 .. 640 nm
- Up to 2 W output power in standard systems, up to 20 W upon request
- Tunable single-frequency emission, typ. linewidth < 500 kHz
- Examples:
  2 W at 589 nm for Na laser cooling,
  > 250 mW at 556 nm for Yb laser cooling



Schematic of the DL-FA-SHG pro / DL-RFA-SHG pro system: high power with outstanding stability.

DL-FHG pro

Frequency Quadrupled Diode Lasers

DL-FHG pro—tunable, narrow-linewidth, deep-UV cw laser source.

Key features

- Tunable “deep-UV” laser radiation 215 .. 315 nm
- 1 .. 4 nm coarse tuning
- 50 µW to 1 mW output power
- Single-frequency emission, typ. linewidth < 1 MHz
- Probe beam output of fundamental laser
- Beam shaping of SHG and FHG radiation included
- High power upgrade possible (depending on amplifier availability)
- Fiber coupling of probe beam optional

Taking diode lasers to the deep UV

More and more scientific applications long for medium-power, single-frequency cw lasers in the deep UV. In order to provide researchers with suitable sources, TOPTICA has developed the DL-FHG pro laser platform. Uniting an external-cavity diode laser and two cascaded frequency doubling stages, single-frequency radiation at wavelengths from 215 nm .. 315 nm is realized. The system comes with complete driving electronics (one double stage DC 110/19" rack and – if required – an additional single stage DC 110/19" rack). Further modules for frequency stabilization or even linewidth narrowing can be added.

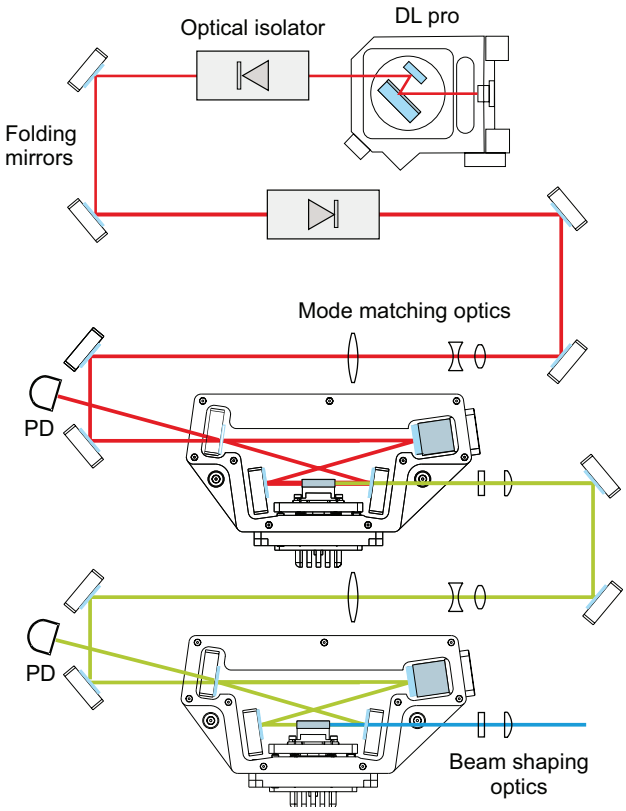
Pro design for outstanding ease of use and stability

Despite the challenge of mastering two frequency-doubling steps, the DL-FHG pro platform provides an excellent stability. This is a result of many years of R&D at TOPTICA. Careful selection of efficient NLO crystals, stable SHG resonators and Pound-Drever-Hall locking for both stages – in short, the pro design – make the difference between self-built lasers and our solution. Optionally and strongly recommended, a fast double-piezo stabilization of the SHG resonators can be integrated to increase the locking bandwidth and the output power stability.

Typical power levels are in the 50 µW to 1 mW range, typical mode-hop free tuning is more than 30 GHz, coarse tuning with mirror alignment is on the order of 1–4 nm. Special solutions with increased fine tuning are available upon request.

DL-FHG pro applications

The medium power UV laser DL-FHG pro lasers are mainly used to photo-ionize atoms (e.g. Mg), for laser cooling of single ions (e.g. Be+, Mg+) or in high-resolution spectroscopy as required in ion-type atom clocks (e. g. Al+).



Schematic of the DL-FHG pro system: medium power laser radiation at deep-UV wavelengths.

TA-FHG pro

Frequency Quadrupled Amplified Diode Lasers

Deep UV meets high power

Smallest focal diameters in wavelength-sensitive chemical reactions, advanced spectroscopy or frequency metrology: Applications for high power laser sources in the deep UV are manifold, and so are the demands on the laser. Best possible beam quality, long coherence length, true cw operation – and everything in a reliable setup?

TOPTICA's TA-FHG pro consists of a grating-stabilized diode laser as fundamental light source, a high power semiconductor amplifier, and two cascaded second harmonic generation stages for producing fourth harmonic light. The system can be understood as a TA-SHG pro plus an additional SHG pro, everything included in one solid laser head and equipped with state-of-the-art electronics. Neither an external pump source nor water cooling are required. A probe output of the fundamental laser and optionally also of the frequency-doubled laser is provided.

cw, single-frequency and tunable

The TA-FHG pro lasers are customized solutions for wavelengths in the range of 205 nm – 270 nm. Typical coarse tuning with minor realignment is 1 – 4 nm, typical mode-hop free tuning is > 30 GHz, and output powers up to 40 mW are available. See "Specifications Frequency Converted Lasers", page 43, for further information.

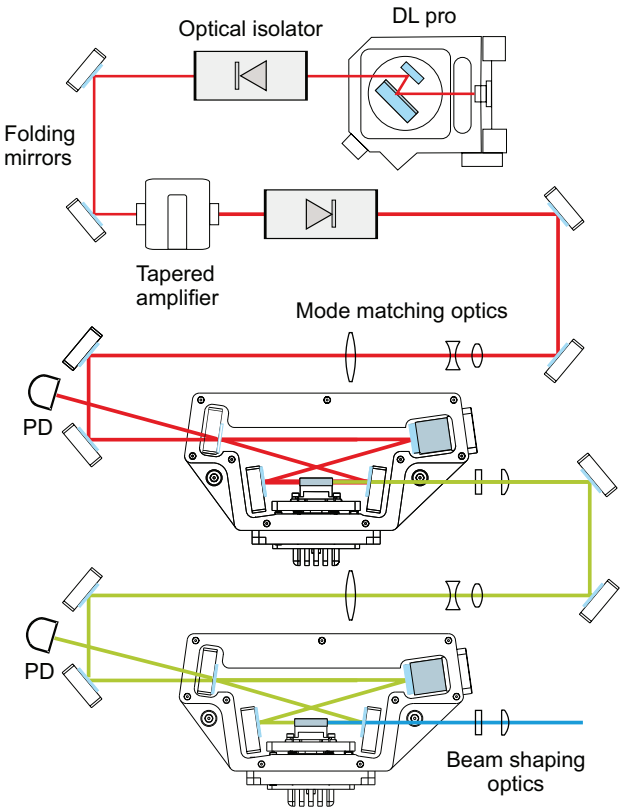
TA-FHG pro applications

The TA-FHG pro laser lends itself to ultra-high-resolution spectroscopy, like studies of atoms (e.g. Hg, H) and ions (e.g. Mg, Yb, Al, In). Applications beyond basic research include industrial imaging and interferometry, ellipsometry, and photo electron spectroscopy. Customers in material science benefit from the excellent beam quality and the continuous UV laser emission – a point of particular relevance for lithography, glue curing or polymer hardening.

TA-FHG pro – single-frequency deep-UV laser with high output power.

Key features

- Tunable "deep-UV" laser radiation 205 .. 270 nm
- 1 mW to 40 mW output power
- Single-frequency emission, typ. linewidth < 1 MHz
- Probe beam output of fundamental laser
- Beam shaping of SHG and FHG radiation included
- Fiber coupling of probe beam optional



Schematic of the TA-FHG pro system: high power in the deep UV.

DL-(R)FA-FHG pro

Frequency Quadrupled Fiber Amplified Diode Lasers

DL-FA-FHG pro and DL-RFA-FHG pro: single-frequency UV laser based on fiber amplified diode lasers.

Key features

- Tunable “deep-UV” laser radiation 260 .. 320 nm
- 5 mW to 100 mW output power (mainly limited by NLO crystal lifetime)
- Single-frequency emission, typ. linewidth < 1 MHz
- Probe beam output of fundamental laser
- Easy manual crystal shift with closed SHG pro cavity
- Fiber coupling of probe beam optional

UV power in the 260 .. 320 nm range

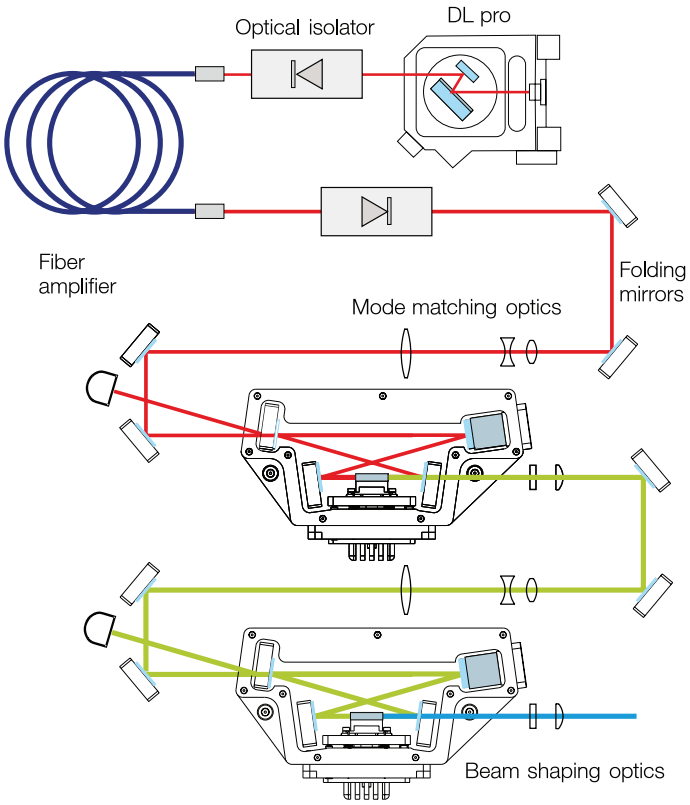
Some applications require power levels still higher than those of the frequency quadrupled diode lasers (DL-FHG pro/ TA-FHG pro) presented so far. A boost in output power at several UV wavelengths can be achieved by integrating a Fiber Amplifier (FA) or Raman Fiber Amplifier (RFA) between the external-cavity diode laser and the first of two sequential frequency doubling cavities. In other words, the DL-FA-FHG pro and DL-RFA-FHG pro systems are the frequency-quadrupled counterparts of the frequency-doubled systems DL-FA-SHG pro and DL-RFA-SHG pro presented on page 37. All of the pro series characteristics – easy handling, high acoustic and temperature stability, fine and coarse tuning and many more – are maintained. The DL pro-type diode laser and the two SHG pro frequency doubling resonators are all contained in one laser head, with two fiber links connecting the external fiber amplifier.

Overdriving for ultimate Power

The power capability of these systems is extraordinary. If required, significantly higher power levels than the specified value can be obtained at many wavelengths if one is willing to sacrifice hands-free operating time. At high UV power (typ. > 30 – 100 mW, wavelength dependent) the NLO crystal of the second doubling stage might degrade with time, and decrease the output power. Shifting of the crystal, which can be done conveniently in two directions while keeping the SHG pro cavity closed, will however restore the UV power.

Applications

Frequency quadrupled fiber amplified diode laser systems are mainly used in ion trapping experiments and atom cooling experiments. Examples are: Mg ionization or laser cooling at 285 nm, Mg+ laser cooling at 280 nm, Be+ laser cooling.



Schematic of the DL-FA-FHG pro / DL-RFA-FHG pro system: UV power at exotic wavelengths

Inventive Frequency Converted Solutions

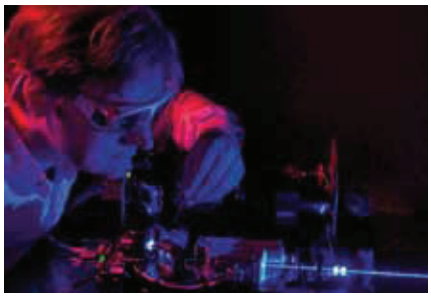
Solutions from the Specialists

Closing even more spectral gaps
TOPTICA takes pride in offering the broadest wavelength coverage in tunable diode lasers. We draw on our profound expertise not only with laser diodes, semiconductor and fiber amplifiers, but also on our understanding of frequency conversion techniques. Even at the most "exotic" wavelengths, we are able to offer inventive solutions – in fact, almost any wavelength between 205 nm and 3000 nm can be reached.

Sum Frequency Generation (SFG)
SFG is a powerful tool for producing short-wavelength laser radiation. Output beams of two fundamental lasers are superimposed in a nonlinear crystal, which converts two photons with frequencies ω_1 and ω_2 into one photon with frequency $\omega_1 + \omega_2$. In TOPTICA's TA-SFG laser system, light of a tapered amplifier TA pro is coupled into an enhancement cavity (SHG pro), and overlapped with a second laser beam, e.g. a frequency doubled Nd:YAG at 532 nm, that traverses the nonlinear crystal in a single pass. Thus, new wavelengths especially in the UV range can be addressed. One example is tunable single-frequency light at 355 nm with more than 30 mW of output power.

Fourth Harmonic Generation of a third party laser (FHG)
And even frequency quadruplicating of a third-party laser is by no means out of reach. This could be a Ti:Sa laser, a fiber laser, a non-standard amplified diode laser or a single-frequency OPO laser. In one of our inventive projects, we successfully frequency quadrupled a 2.4 µm laser to obtain > 100 mW around 600 nm. In another case, we offered a special, frequency-quadrupled diode laser system for Be+ cooling at 313 nm.

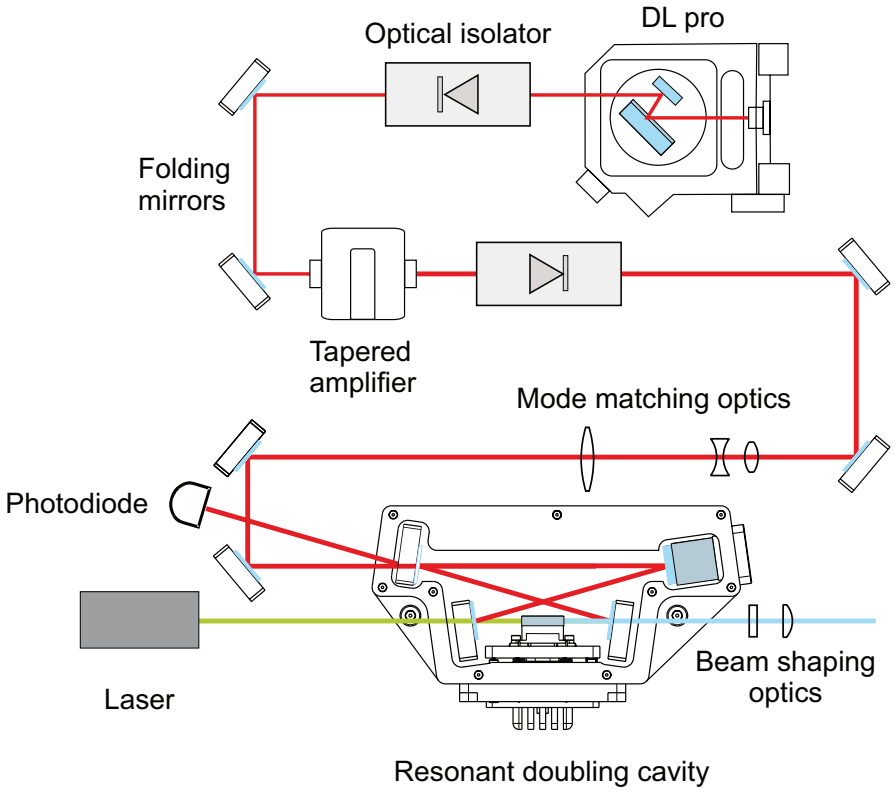
If you have a related requirement, feel free to challenge us. We are proud of our "crazy" ideas for unique solutions.



TOPTICA specialist aligning a customized frequency converted laser system.

Key features

- Unique developments for non-standard requirements
- Access to unusual wavelengths or power levels
- pro technology wherever possible
- On demand, third party lasers or specially developed amplifiers may be included
- Solutions where other suppliers fail



Schematic of an SFG solution: a TA pro type laser is mixed with a high power laser, e.g. a frequency-doubled Nd:YAG.

TOPSeller Systems

Preconfigured Lasers for Selected Applications

TOPSeller DL-SHG pro and TA-SHG pro systems for selected applications: Rydberg excitation and Sr, Ba+, Ca+ laser cooling

Key features

- One laser head from a solid metal block + one double stage 19" DC 110 rack containing all required control modules
- Air sealed SHG pro resonator with height adjustment of NLO crystal
- Dual channel Pound-Drever-Hall detector module (PDD/F/Dual) included
- Tunable single-frequency emission with output power matched to the requirements of the selected application
- Optional: Probe beam output of fundamental laser, and fiber coupling of probe beam or SHG output

Preconfigured laser systems

TOPTICA's TOPSeller NLO systems are designed for some of the most common applications of our frequency-converted systems. All TOPSellers feature a dual-channel Pound-Drever-Hall module for frequency stabilization of the master laser, either to an external resonator via the Pound-Drever-Hall method, or to an atomic/molecular reference via FM spectroscopy. Optional add-ons are the double-piezo lock of the SHG resonator, an integrated electro-optic modulator (to be used for Pound-Drever-Hall frequency modulation, instead of the laser diode current), fiber coupling of the probe beam and/or the SHG output, and additional locking modules like DigiLock 110 and FALC 110.

Rydberg excitation

Two TA-SHG pro systems are preconfigured for Rydberg excitation of Rb atoms. Both provide more than 250 mW output power over the specified coarse tuning range and more than 15 GHz mode-hop free tuning. The typical short term linewidth is 200 – 300 kHz. **"Syst RYDBERG I"** (coarse tuning 474 nm – 480 nm) and **"Syst RYDBERG II"** (coarse tuning 479 nm – 486 nm) are designed for Rydberg excitation via the Rb D1 and D2 line, respectively.

Sr laser cooling

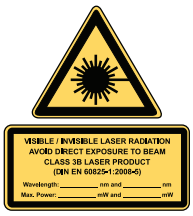
The **"Syst SR COOLING"** laser provides 250 mW in the wavelength range of 458 – 461 nm. Here, > 10 GHz mode-hop free tuning and a short-term linewidth below 500 kHz are specified. On demand, a high-power version of the system can be realized, providing power levels up to 400 mW.

Ba+ laser cooling

Two frequency converted laser systems are available for laser cooling of Ba ions. **"SYST BA+ COOLING"** is a DL-SHG pro-type system with 20 mW in the wavelength range of 492 – 495 nm, with > 10 GHz mode-hop free tuning and "pro" specifications for linewidth (< 500 kHz, typ. 200 – 300 kHz) and stability. For higher output power, the TA-SHG pro system **"SYST BA+ COOLING HP"** offers > 250 mW output power. Note that latest laser diode developments allow for 5 mW output at 493 nm directly from a DL 100 / pro design laser.

Ca+ laser cooling

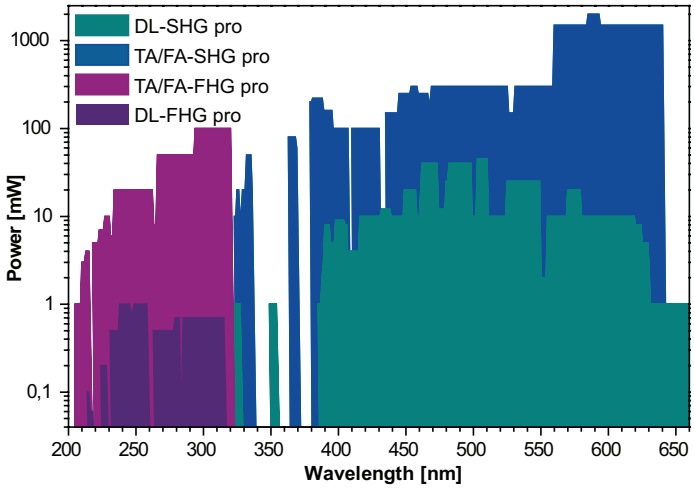
High output power of > 100 mW at 397 nm with 2 nm coarse tuning and > 10 GHz mode-hop free is provided by the TA-SHG pro laser **"SYST CA+ COOLING HP"**. The probe beam output at the fundamental wavelength (792 – 796 nm) can be conveniently used to stabilize the laser to external references, such as a High Finesse wavelength meter (pages 60–61). Note, latest laser diode developments allow for 5 – 10 mW output power around 397 nm and 5 mW around 422 nm from a DL 100 / pro design laser.



Specifications

Comparison of Frequency Converted Solutions

Specifications		
	DL-SHG pro / TA-SHG pro DL-FA-SHG pro / DL-RFA-SHG pro	**DL-FHG pro / TA-FHG pro DL-FA-FHG pro / DL-RFA-FHG pro**
Center wavelengths	390 .. 630 nm* / 323 .. 541 nm* 520 .. 562 nm / 560 .. 640 nm	215 .. 315 nm* / 205 .. 270 nm* 260 .. 281.6 nm / 280 .. 320 nm
Typical power range	1 .. 40 mW / 20 .. 400 mW 200 mW .. 10 W / 1 .. 10 W (20 W u. r.)	50 .. 1000 µW / 1 .. 20 mW 5 .. 40 mW / 20 .. 100 mW
Typical tuning range	1 .. 9 nm	1 .. 4 nm
Typ. mode-hop free tuning range up to	~ 20 GHz	~ 30 GHz
Typ. linewidth (ms)	500 kHz	1 MHz
Long term frequency change with room temperature**	< 200 MHz / K	< 400 MHz / K
Spatial mode	Nearly diffraction limited	
Beam height	50 mm	
Probe beam output	Fundamental light with ~ mW power level	
Polarization linear	< 1:1000	
Power stability of frequency converted light	< 3 %, typ. < 1 %***	
Residual infrared unfiltered	< 5 % (filtered < 0.1 %)	
Warm-up time	Few minutes, depending on crystal temperature	
Environment temperature operating	15 .. 30°C, Transport: 0 .. 40°C	
Humidity	non condensing	
Operating voltage	100 .. 120 V / 220 .. 240 V AC, 50 .. 60 Hz (auto detect)	
Power consumption	Typ. < 120 W, max. 300 W	Typ. < 150 W, max. 600 W
Size laser head (L x W x H)	400 x 380 x 90 mm^3 (+ external fiber amplifier)	400 x 566.5 x 90 mm^3 (+ external fiber amplifier)
Electronics	Double stage 19“ rack (+ 19” rack for Raman fiber amplifier)	Double stage 19“ rack + additional rack if required (+ 19” rack for Raman fiber amplifier)
*Spectral coverage with gaps. **Under stable laboratory conditions. ***Lower amplitude noise with noise eater option (TA-SHG/FHG).		



Wavelength coverage of TOPTICA's frequency converted systems.