

Technical University of Denmark



Visible and ultraviolet light sources based nonlinear interaction of lasers

Andersen, Martin Thalbitzer; Tidemand-Lichtenberg, Peter; Jain, Mayank; Pedersen, Christian

Publication date:
2009

[Link back to DTU Orbit](#)

Citation (APA):

Andersen, M. T., Tidemand-Lichtenberg, P., Jain, M., & Pedersen, C. (2009). Visible and ultraviolet light sources based nonlinear interaction of lasers. Poster session presented at UK Luminescence and ESR Meeting 2009, London (GB), 26-28 Aug., .

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



Visible and UV light sources based on nonlinear interaction of lasers

M. T. Andersen¹, P. Tidemand-Lichtenberg², M. Jain¹, C. Pedersen¹

1. Radiation Research Division, Risø National Laboratory for Sustainable Energy, Technical University of Denmark, DK-4000 Roskilde, Denmark.
2. Quantum Physics and Information Technology, Department of Physics, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark.

1. Abstract

Different light sources can be used for optically stimulated luminescence measurements. Usually a halogen lamp in combination with filters or light emitting diodes (LED's) are used to provide the desired stimulation wavelength. However lasers can provide a much more well-defined beam, very narrow spectrum, high intensities and fast pulsing characteristics. Apart from potential significant reduction in filtration requirements as compared to the LED's, these characteristics help in accurate examination of different trap parameters. In this poster recent work on a general approach for effectively synthesizing any wavelength in the visible and ultraviolet light based sum frequency generation between two lasers is presented.

2. Introduction

The development of efficient, compact and robust laser sources in the visible and UV spectral range is the subject of intensive research, for applications in areas as diverse as optical spectroscopy, projection displays, bio- and chemical sensing, and biomedical diagnostics. The generation of visible light from optically-pumped solid-state and semiconductor lasers is usually achieved via second harmonic generation (SHG), as the transition lines of most conventional doped dielectric laser crystals and the bandgaps of the most common III-V semiconductor alloys are in the near infrared region (NIR). Using this general approach based on sum frequency generation (SFG) between two laser sources, effective generation of light can be achieved at hard to get wavelength, and "green noise" can be avoided.

3. Singly resonant setup

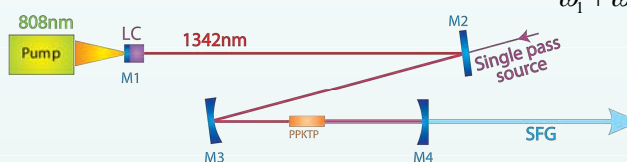
- Nonlinear media placed intracavity in one of the lasers
- No coupling between the modal gain of the two lasers
- High single pass conversion efficiency

Second Harmonic Generation

$$2\omega_1 = \omega_{SHG}$$

Sum Frequency Generation

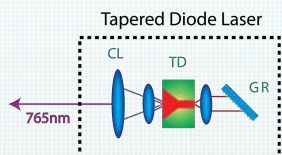
$$\omega_1 + \omega_2 = \omega_{SFG}$$



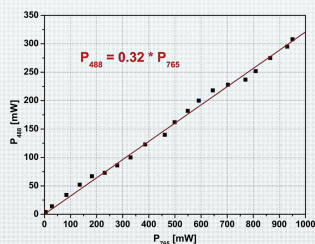
Setup for the resonant 1342nm Nd:YVO₄ solid state laser. M1-M4 are HR@1342nm and HT@808nm, λ_{SP}, λ_{SFG}. The resonator is end pumped by commonly 808nm Broad area laser diode. The nonlinear crystal is a periodically poled KTP quasi phase matching the sum frequency interaction. Appropriate choice of single pass source is effectively converted to the desired wavelength.

4. Continuous Wave 488nm generation (Blue)

Single pass source : 765nm Tapered diode
Resonant laser : 1342nm Nd:YVO₄



Tapered diode (TD) in the Littrow configuration for single frequency operation. CL: Cylindrical lens. GR: Grating



488nm was picked as a proof of principle and to demonstrate a small and compact alternative to the Argon Ion gas laser.

More than 300mW 488nm light was generated with a single pass conversion efficiency of 32%

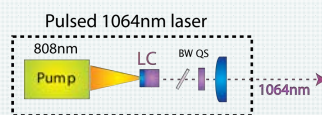
Previous to this work generation of more than 700mW of 593nm has been demonstrated.

This offers a viable and better alternative to the blue LED's in OSL measurements.

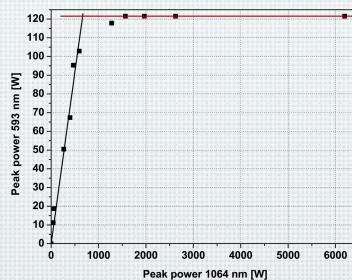
Single pass slope efficiency for a circulating 1342nm power of 200W.

5. Pulsed 593nm generation (Yellow)

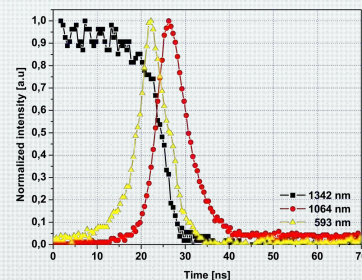
Single pass source : 1064nm Q-Switch Nd:YAG laser
Resonant laser : 1342nm Nd:YVO₄



1064nm solid state Nd:YAG (LC) laser with a Cr:YAG passive Q-switch (QS). The Brewster window forces oscillation at one polarisation.



Saturation of the peak power of the generated 593nm light as function of the 1064nm peak power for a 1342nm circulating power of 50W.

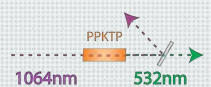


Dynamic of the interaction during single pass pulse propagation through the PPKTP. The resonant power is completely dumped for a single pass peak power of 2.4kW

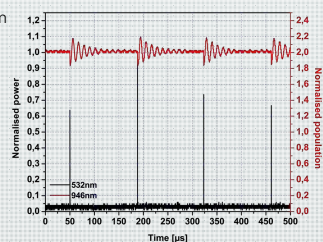
6. Pulsed 340nm generation (UV)

Single pass source : 1064nm Q-Switch Nd:YAG laser
Resonant laser : 946nm Nd:YAG

→ Second harmonic generation: 532nm
 $2\omega_{1064} = \omega_{532}$



→ Sum frequency generation: 340nm
 $\omega_{532} + \omega_{946} = \omega_{340}$



Generation of 340nm light occur when a 532nm pulse (black line) is incident on the nonlinear crystal and the relaxation oscillation for the 946nm laser is seen (red line)

Present sub milliwatt generation of 340nm has been demonstrated

7. Conclusions

- Using the proposed general approach, more than 300mW of CW of 488nm light was generated.
- Pulsed operation was demonstrated by generating 120W of 593nm peak power with a FWHM of 7ns.
- Pulsed generation of 340nm UV light through a cascaded process generating sub milliwatt average power was demonstrated.
- Synthesizing of any wavelength in the visible and UV spectral region, with high efficiency for both pulsed and continuous wave can be realized using this approach.
- These visible light sources generate sufficient power and can have flexible pulsing characteristics (ns timescale) to replace LED's for dedicated OSL applications such as excitation spectroscopy and time resolved OSL measurement.

8. References

E. Karamehmedović, C. Pedersen, M. T. Andersen and P. Tidemand-Lichtenberg, "Efficient visible light generation by mixing of a solid-state laser and a tapered diode laser", *Optics Express* **15**, (2007)
E. Karamehmedović, C. Pedersen, M. T. Andersen and P. Tidemand-Lichtenberg, "300 mW of coherent light at 488 nm using a generic approach", *Photonic West* **6875**, (2008)
P. Tidemand-Lichtenberg, M. T. Andersen, S. Johansson, C. Canalias, F. Laurell, P. Buchhave, E. Karamehmedović and C. Pedersen, "Nonlinear cavity dumping of a high finesse frequency mixing module", *Optics Express* **15** (2007)
J. Janousek, S. Johansson, P. Tidemand-Lichtenberg, S. Wang, J. Mortensen, P. Buchhave, and F. Laurell, "Efficient all solid-state continuous-wave yellow-orange light source", *Optics Express* **13**, (2005)