50 years of the Institute of High Pressure Physics Polish Academy of Sciences
Highlights in III-V semiconductors, THz physics and nanomaterials
Anniversary Symposium „Unipress 50”

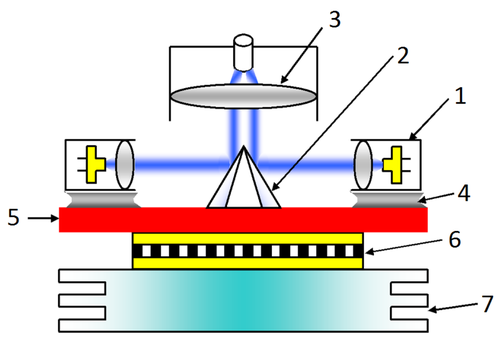
Laser sources for dermatology

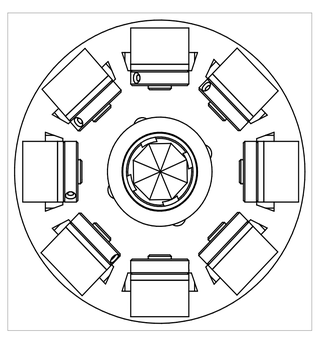
W. Trzeciakowski, Y. Ivonyak, A. Bercha, P. Tuchowski, M. Mrozowicz, B. Piechal

Background

- Rapid development of visible nitride lasers in the last 20 years (from UV to the green). High power blue and green laser diodes (in 9 mm packages) were developed for projector applications.
- Diode lasers seemed more practical and much cheaper than green KTP lasers (frequency doubled Nd:YAG), yellow dye lasers, or CO2 lasers used in dermatology
- High powers (5-50W) and fiber output required for medical applications. Continuous and pulsed operation necessary.
- Combinations of several wavelengths could be superior to a single wavelength.

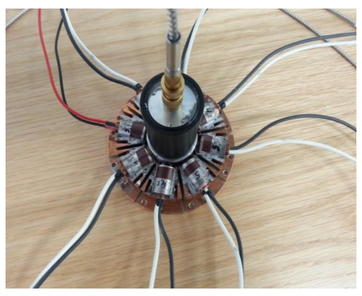
Our method for coupling 8 laser diodes into one fiber (in order to achieve high power in the fiber)

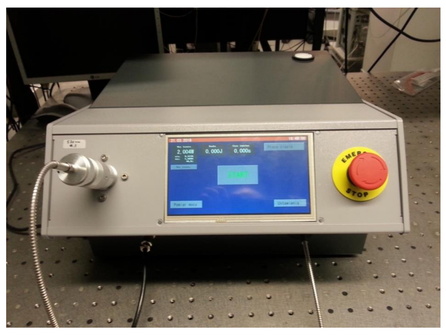




We can achieve high power monochromatic light or mix up to 8 different colors in one fiber (white light can be obtained by mixing red, green and blue) *US patent US 9223123 B2*

Our high-power laser source: CW or pulsed, with touchscreen and power meter, light spot diameter adjustable 0.5-5 mm





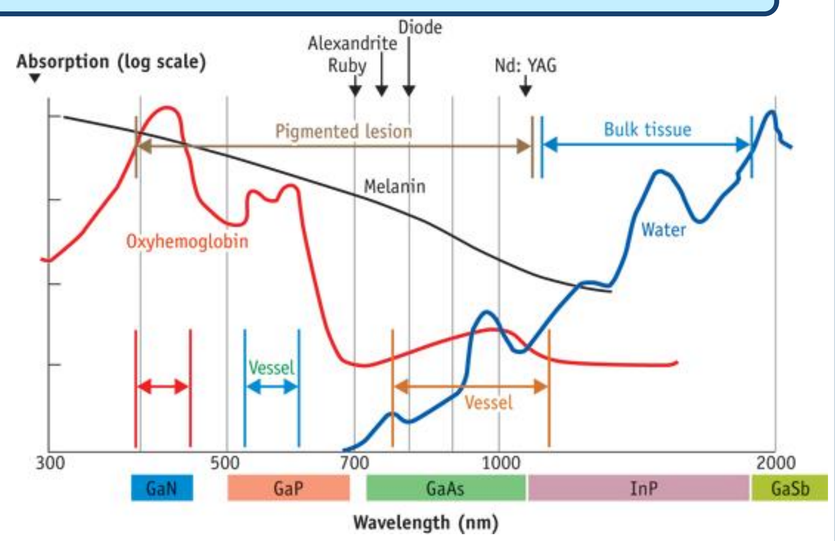
CW power achieved: 3.5W at Violet (410 nm), 50W at Blue (450 nm), 5W at Green (520 nm), 8W at Red (638 nm, with 19x1 fiber combiner). Pulsed operation from 1 ms upwards. Triple-wavelength sources: Red + Green + Blue and Red + Violet + Blue for oral PDT

Relevant medical publications

1. Blue Laser (450 nm) in the Treatment of Port Wine Stains and Telangiectasia, *Journal of Clinical Medicine* 2021, *10*(6), 1258;
2. „High power blue laser as a versatile tool in dermatology” *Journal of Cosmetic Dermatology* 2021, https://doi.org/10.1111/jocd.14432
3. „Assessment of Effects of Laser Light Combining Three Wavelengths (450, 520 and 640 nm) on Temperature Increase and Depth of Tissue Lesions in an Ex Vivo Study”. *Materials* 2020, *13*, 5340, doi:10.3390/ma13235340.
4. „Assessment of Human Gingival Fibroblast Proliferation after Laser Stimulation In Vitro Using Different Laser Types and Wavelengths (1064, 980, 635, 450, and 405 nm)”, *Journal of Personalized Medicine* 2021, *11*(2), 98;
5. „Photodynamic Diagnosis and Photodynamic Therapy in Basal Cell Carcinoma Using Novel Laser Light Source”, *Photodiagnosis and Photodynamic Therapy* (2020)
6. „The effect of in vitro photodynamic therapy on increase of osteopontin and heat shock protein 70 expression in squamous cell and colon carcinoma" *IEEE J.Sel.Top.Quantum Electron.* 2019 Vol.25 no.1; art.7201107.
7. „Fractal Dimension and Texture Analysis of Lesion Autofluorescence in the Evaluation of Oral Lichen Planus Treatment Effectiveness”, *Materials* **2021**, 14, 5448. https://doi.org/10.3390/ma14185448
8. „Blue Laser (450 nm) Treatment of Solar Lentigines” *Journal of Clinical Medicine* **2021**, *10*, 4919. https://doi.org/10.3390/jcm10214919

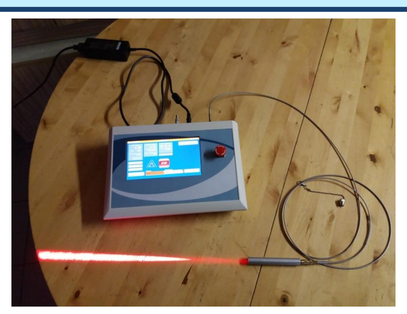
Absorption of light by three main chromophores in human tissue

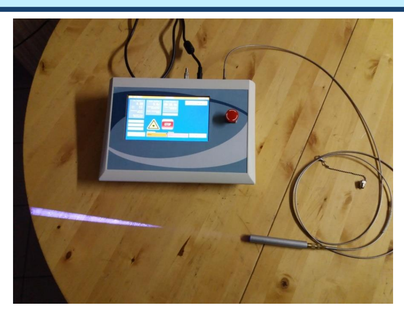
Visible range is important for the treatment of vascular lesions due to strong absorption by hemoglobin and melanin. However, strong absorption means shallow penetration. Yellow light around 590 nm (pulsed dye lasers) was considered the best for reaching blood cells and having good absorption by hemoglobin.



We chose to work at shorter wavelengths but we were not sure if the penetration depth was sufficient.

Two-color lasers for photodynamic therapy and diagnosis





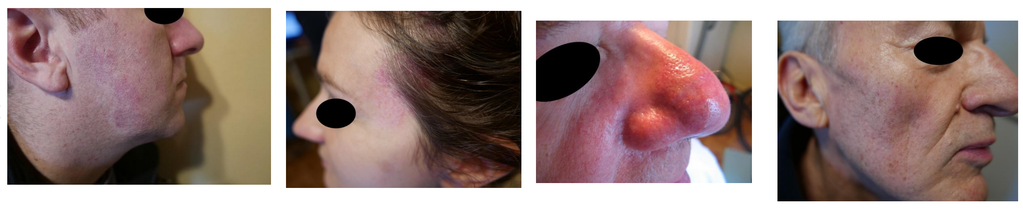
Here we used a dielectric edge filter (at 45 degrees) which reflects 410 nm beam and transmits a 638 nm beam.

Red light (638 nm, 400 mW) and violet light (410 nm, 400 mW) from the same fiber.

Positive clinical results for PWS, telangiectasia and solar lentigines (blue laser with 15 ms pulses and 48 W peak power)

Before treatment

After treatment



High-power blue laser as a surgical tool (replacing CO2 laser): plantar warts

Before treatment

After treatment

Use this QR code to see the poster on-line