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Stimulated Raman scattering in crystals and applications

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Stimulated Raman scattering (SRS) is a third-order nonlinear optical effect and has been observed in more than 120 crystals which we pumped using pulsed Nd:YAG lasers at 1064 nm, 532 nm or 355 nm wavelength. More than 2000 SRS lines have been observed covering the spectral region from 300 nm to 3500 nm. Frequency conversion by SRS has been established as a versatile method to produce laser radiation at specific wavelengths which cannot be obtained with conventional laser materials. Prominent Raman crystals include $BaNO_3$ and other nitrates, KGW and other tungstates, YVO_4 and other vanadates as well as diamond. These crystals exhibit lattice vibrations with wave numbers from 80 cm^{-1} to 3150 cm^{-1} shifting the incident laser wavelength to higher or lower values. Recently, we observed SRS in the natural crystal spodumene (α-$LiAlSi_2O_6$) and in $LuAlO_3$. Moreover, generation of wide frequency combs via SRS, with equidistant lines in the frequency domain, has opened a new path of research on ultrashort pulse synthesis. Efficient amplification of a specific Raman frequency component is possible by placing the Raman crystal into a frequency-selective optical resonator. This configuration strongly decreases the SRS threshold and results in low-divergent laser radiation at the desired wavelength. Raman lasers can be used in many applications, e.g. differential absorption LIDAR systems (DIAL, light detection and ranging) to detect trace gases like carbon dioxide or ozone. Following this approach, a substantial extension of the spectral coverage by solid-state lasers has been achieved over the last five decades. Various pumping schemes and resonator designs have been investigated focusing on good conversion efficiency, high spatial beam quality and high pulse energy of the output beam.

Recent Publications

1. Lux O, Ralchenko V G, Bolshakov A P, Konov V L, Sharanov G V, Shirakawa A, Yonada H, Rhee H, Eichler H J, Mildren R P and Kaminskii A A (2014) Multi-octave frequency comb generation by χ(3)-nonlinear optical processes in CVD diamond at low temperatures. Laser Physics Letters 11(8).
2. Kaminskii A A, Bohaty L, Libowitzky E, Rhee H, Lux O, Eichler H J, Kleinschrodt R, Yoneda H, Shirakawa A and Becker P (2018) Spodumene, α-LiAlSi2O6 – a new natural SRS-active crystal with three χ(3)-promoting vibrational modes. Optical Materials 78:235-246.
3. Lux O, Fritsche H and Eichler H J (2013) Trace gas remote sensing by lasers - solid-state laser systems enable carbon dioxide and methane detection. Optik and Photonik 48-51.
4. Kaminskii A A, Bohatý L, Lux O, Rhee H, Eichler H J, Libowitzky E, Kleinschrodt R, Yoneda H, Shirakawa A and Becker P (2016) Stimulated Raman scattering in natural crystals of fluorapatite $Ca5(PO_4)3F$. Laser and Photonics Reviews 10(5):814-825.
5. Kaminskii A A, Lux O, Ralchenko V G, Bolshakov A P, Rhee H, Eichler H J, Shirakawa A and Yoneda H (2016) High order Stokes and anti- Stokes Raman generation in monoisotopic CVD 12C-diamond. Physica Status Solidi 10(6):471-474.

Biography

Christoph Zesch is a PhD student at the University of Rome Tor Vergata and works as a Scientific Employee at the Technical University of Applied Sciences Wildau and the Technical University Berlin. He received the Master of Engineering at the Technical University of Applied Sciences Wildau in 2017. His expertise is in Nonlinear Optics and Laser Spectroscopy especially in stimulated Raman scattering and solid state Raman lasers and amplifiers.

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