LED-pumped CTH:YAG luminescent concentrator as broadband incoherent source in the SWIR

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CTH:YAG is a laser medium know for many years [1]. The atmospheric transmission properties and eye safe nature of this laser emitting at 2.1 µm make it attractive for many applications. Thanks to efficient energy transfer between Cr^{3+}, Tm^{3+} and Ho^{3+}, CTH:YAG has often been pumped in the visible by flashlamps [2]. CTH:YAG has also a remarkable broadband spectrum spanning from 1.7 µm to 2.15 µm. Sensing and inspection applications are growing with the emergence of low-cost image sensors in the SWIR range. Illumination sources in this wavelength band are limited: halogen, black body and low power LEDs. The purpose of this work is to show that CTH:YAG opens opportunities for innovative, high-brightness, spectrally-broadband and incoherent sources in the SWIR.

As pump source, we used a Ce:YAG luminescent concentrator (LC) [3], since CTH:YAG absorption band matches the Ce:YAG yellow emission. A 1×14×220 mm^3 Ce:YAG is pumped by 2240 blue LEDs (Fig.1a). A 1×3×14 mm^3 CTH:YAG is bonded on the output surface by an UV-curing optical adhesive. Total internal reflections are preserved by the index difference between CTH:YAG (n=1.82) and the adhesive (n=1.5). The CTH:YAG sample operates as a LC with a maximum brightness on the smallest face (1×3mm^2) chosen as the output face. A gold mirror is positioned on the opposite face to increase the output power.

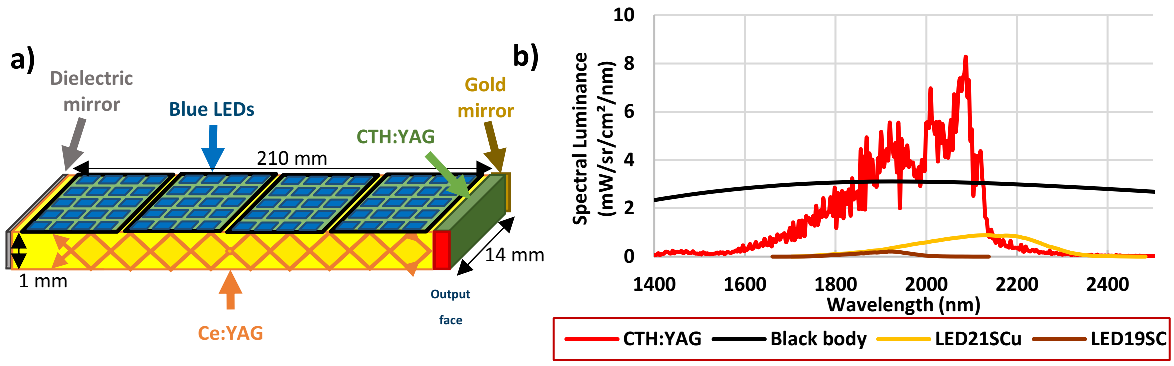

Figure 1: a) Scheme of the cascade of concentrators with blue LEDs pumping Ce:YAG that pumps CTH:YAG
b) Spectral brightness of a blackbody at T=1500 K, two infrared LEDs manufactured by Boston electronics and our CTH:YAG concentrator. (The black body operates continuously, the other sources in QCW.)

LEDs operate in quasi-continuous wave with 260 µs pulses at 10 Hz and a peak power of 3.15 W per LED. The Ce:YAG delivers a peak power of 1,7 kW towards the CTH:YAG. The spontaneous emission from the output face is collected by an integrating sphere photodiode power sensor (S148C Thorlabs). We measured a SWIR peak power of 50 mW on a 1.6 to 2.1 spectrum (Fig1 b). Despite a low efficiency, the spectral brightness is 3 times higher than the one of a black body at T=1500 K and approximately 10 times higher than LEDs operating in this wavelength range. Many improvements are possible regarding crystal cooling, light extraction and pump duration (as CTH:YAG lifetime is 8.5 ms). This first result proves that a LED pumped cascade of concentrators has a potential for alternative SWIR sources with applications like active imaging.

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[2] Dan Bar-Joseph "2.097µ Cth:YAG flashlamp pumped high energy high efficiency laser operation (patent pending)", Solid State Lasers XXVII: Technology and Devices, Proc. SPIE **10511**, 1051107 (2018)
[3] P. Pichon, A. Barbet, J-P. Blanchot, F. Druon, F. Balembois, and P. Georges, "LED-pumped alexandrite laser oscillator and amplifier”, Optics Letters, **42**, pp.4191-4194 (2017).