All passive 1.1mJ Tm:YLF/KGW Raman Laser at 2262nm

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Short wave-infrared (SWIR) coherent sources continue to draw much attention, as the efforts to develop high power lasers covering this spectral range continue to increase due to many applications such as LIDAR, microsurgery, material processing of polymers and metals, defense applications [1]. Solid-state Raman lasers are a very efficient method of extending the spectral range of high-brightness sources [2]. potassium gadolinium tungstate ($KGd(WO_4)_2$ or KGW is a good Raman gain medium due to its attractive thermal properties and very high damage threshold, allowing for high energy pumping.

Moreover, because KGW is a biaxial crystal, it has Raman interaction with two different vibrational modes (901 cm^{-1} and 768 cm^{-1}) providing the option to obtain two different Stokes wavelengths by controlling the polarization of the pump laser beam, yielding two corresponding output wavelengths at 2195nm and at 2262nm.

Presented here is the first demonstration of a KGW Raman laser in an all passive configuration producing a mJ per pulse output energy in the SWIR regime.

1. EXPERIMENTAL SETUP

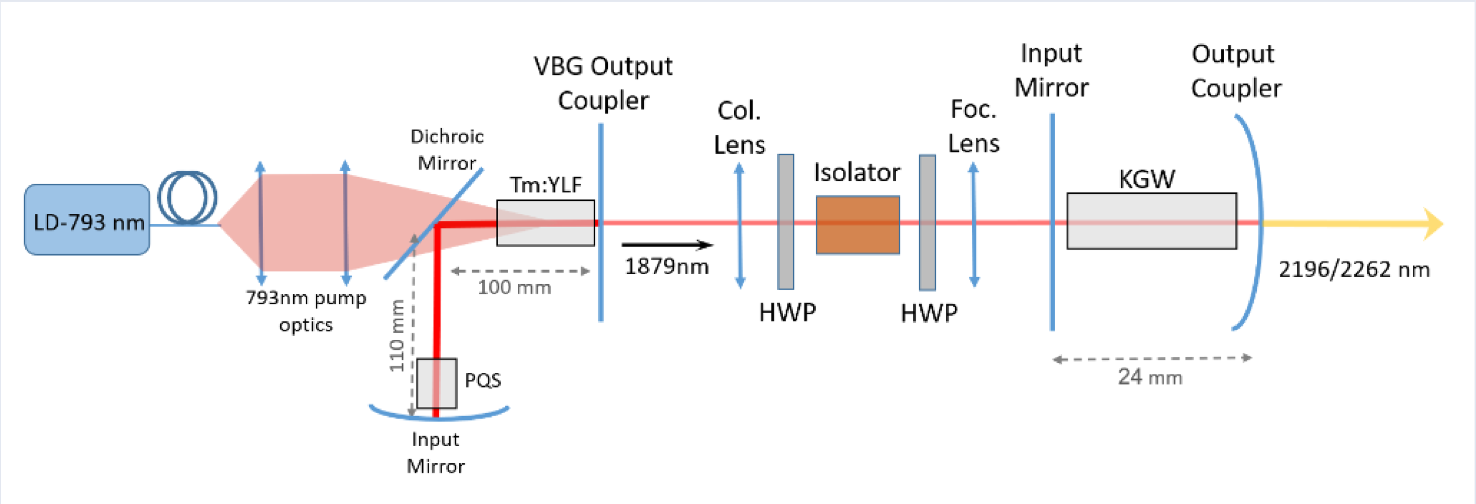

Figure 1: Schematic of external Raman laser and its Tm:YLF fundamental pump laser

The fundamental laser is a passively Q-switched Tm:YLF laser with an L-shaped cavity. The emitted wavelength from the Tm:YLF laser is 1880nm [3]. The Tm:YLF laser beam is collimated and focused through an isolator with two HWP, to a spot size of 260 um in radius onto the Raman crystal. Rotation of the HWP controls the polarization of the laser beam, selecting which of the two wavelengths will be emitted by the Raman laser, corresponding to the two orthogonal stokes shifts of the KGW.

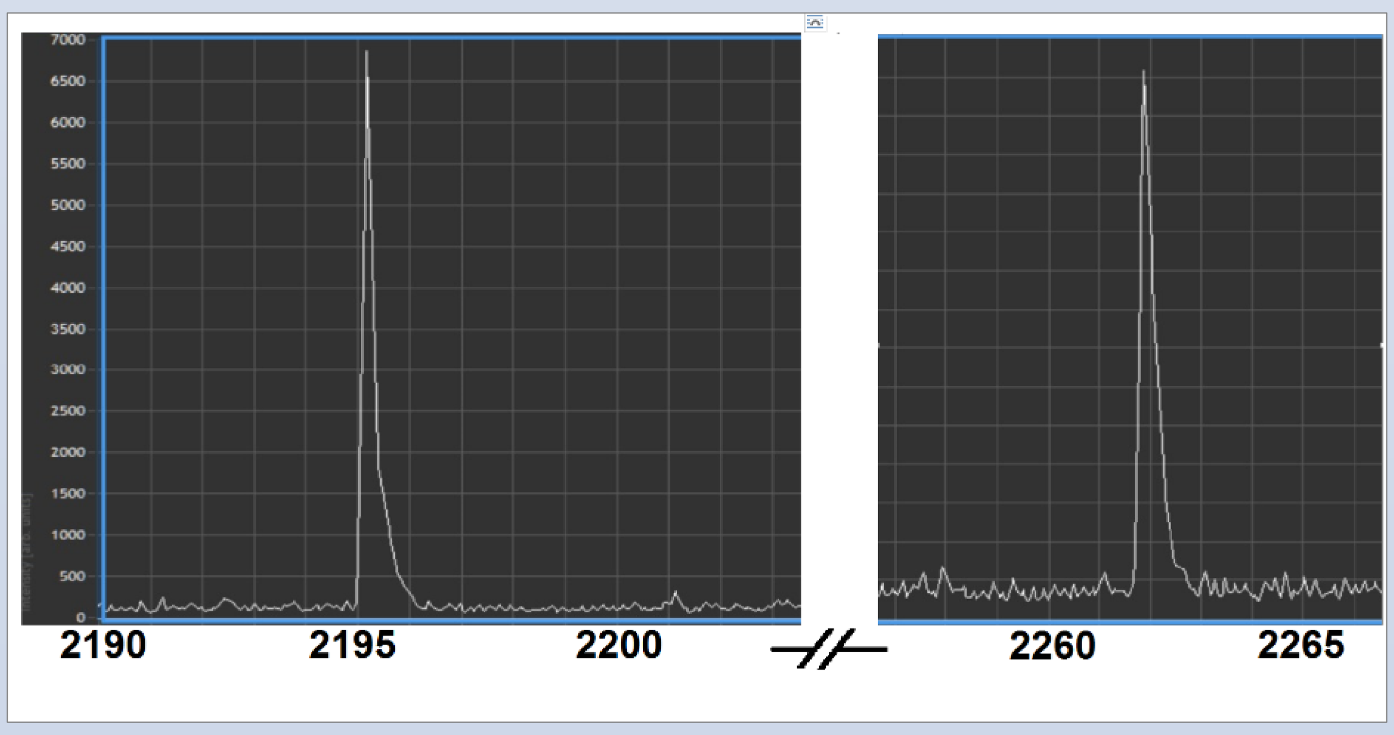

Figure 2: Spectrum of 2195 nm line (left) and 2262nm line (right)

The Raman laser cavity has a plano input mirror and an output coupler with partial reflectance of 60% at 2200nm and a radius of curvature of 50 mm. A 20-mm-long KGW crystal is used as the gain medium and the cavity length is 24mm in total.

2. RESULTS

The KGW Raman laser performance is shown in table 1. The Raman laser threshold is about 2mJ of pump energy. The energy output versus pump energy is shown in Fig.3. The lower results of the 786 cm^{-1} shift compare to the 901 cm^{-1} shift is because our mirrors coating , support unintentionally, the second stocks existence of this polarization shift at higher wavelength.

	901 cm^{-1}	768 cm^{-1}
Wavelength	2262 nm	2195.5 nm
Energy per Pulse	1.1 mJ	0.57 mJ
Pulse duration	15.6 ns	17.5 ns
Peak-power	70.5 kW	20 kW
Rep Rate	0.615 kHz	0.615 kHz
Conversion efficiency Seed to Raman	34 %	21 %

Table 1: KGW Raman laser performance for each stokes shift

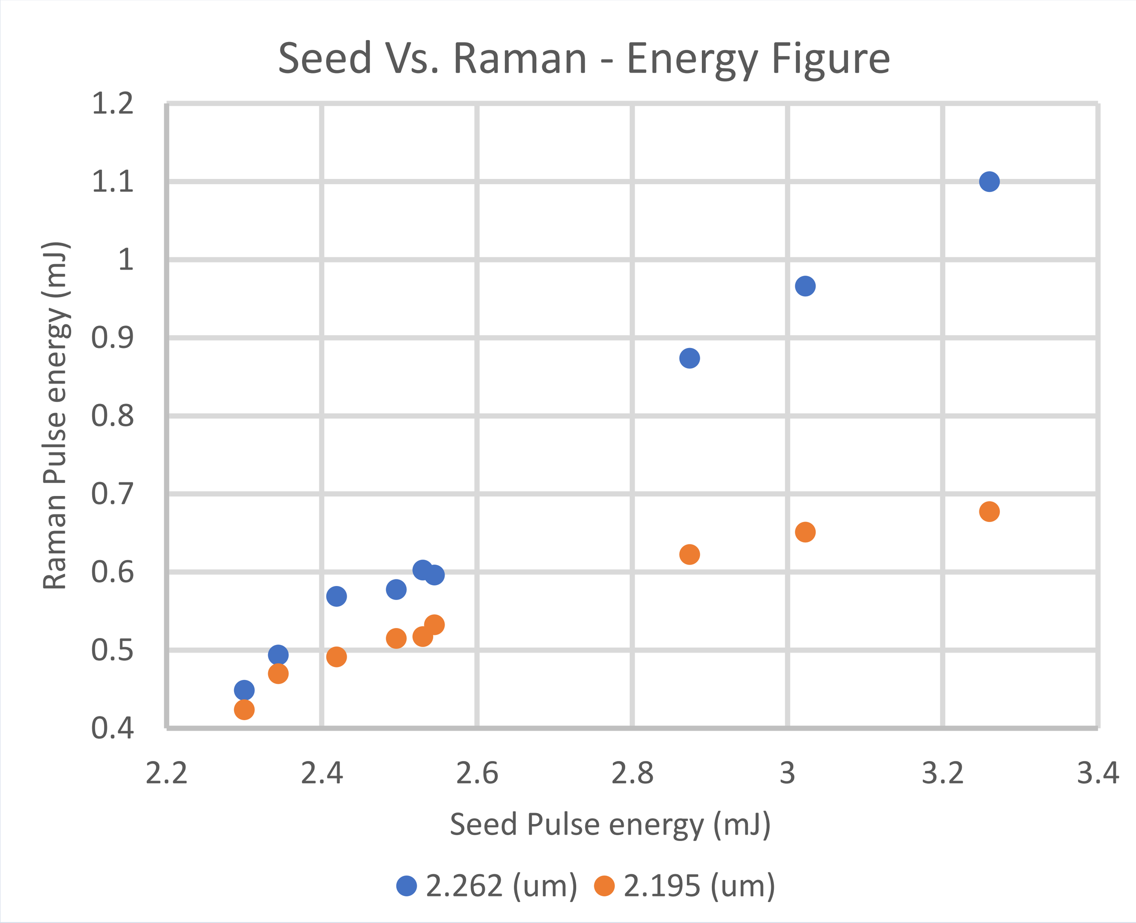

Figure 3: Seed pump energy vs. Raman energy for both wavelengths

The Raman laser M^2 is <1.15 at both wavelengths compared to the M^2~ 1.25 of the Tm:YLF laser seed.

3. CONCLUSIONS

An efficient laser for SRS wavelength conversion in the 2µm region using an external cavity configuration is presented, using a KGW crystal as a Raman gain medium. To the best of our knowledge, this is the highest energy per pulse achieved by a Raman laser in the SWIR spectral range. The KGW is a promising candidate for efficient and high energy SRS conversion in this spectral range.

[1] A. Godard, , "Infrared (2-12 µm) solid-state laser sources: a review" Comptes Rendus Physique 8, 1100-1128 (2007).

[2] H. Pask, "The design and operation of solid-state Raman lasers" Progress in Quantum Electronics 27, 3-56 (2003).

[3] U. Sheintop, E. Perez, D. Sebbag, P. Komm, G. Marcus and S. Noach, "Actively Q-switched tunable narrow bandwidth milli-Joule level Tm:YLF laser," Optics Express 26, 22135 (2018).