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~1400-nm continuous-wave diamond Raman laser intracavity-pumped by an InGaAs semiconductor disk laser

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Semiconductor disk laser (SDL) can produce high brightness continuous-wave output covering most of the spectral region from the red to the mid-infrared band. However, SDL technology based on the multi-quantum-well InGaAs gain structures is the best established and offers very efficient emission in the ~920-1180 nm range. SDLs have also shown exceptional cavity flexibility, allowing the implementation of optical elements into the extended cavity for the nonlinear frequency conversion to cover wavelengths where direct emission is difficult [1]. Laser operation at ~1320 nm has been achieved either by direct emission of a GaInNAs SDL [2] or, more recently, via intracavity Raman conversion of an InGaAs SDL [3].

Here we demonstrate the longest wavelength so far reached by intracavity Raman conversion in an SDL. We used an InGaAs SDL with fundamental emission at ~1180nm. Intracavity first Stokes conversion in a 8mm-long diamond was utilized to produce ~1400 nm collinearly with the SDL beam. Diamond was chosen for its outstanding features: large Stokes shift of ~1332 cm^{-1} and high thermal conductivity (~2 kW/m·K). The experimental setup followed the same scheme presented in the our most recent work [3], and it consisted of two partially-shared 4-mirror high-finesse resonators separated by a tilted dichroic mirror that steered the Raman laser beam to an output coupler of 3.5% transmission. The TEM_{00} SDL beam radius was calculated to be ~150 µm at the SDL gain structure and ~40 µm in the Raman crystal.

A commercial 808-nm diode laser pumped the SDL with up to 67 W in a pump spot radius of ~240 µm. The SDL gain structure surface was capillary-bonded to a wedged 300-µm-thick single-crystal diamond heat-spreader, which was anti-reflection coated for 1180 nm. A 4-mm-thick birefringent filter (BRF) was inserted at the Brewster's angle in the SDL cavity to pin the SDL polarization and to enable tuning. Two uncoated suprasil etalons, with 50 µm and 200 µm of thickness, were added in the SDL resonator to provide narrow fundamental emission and thus to enhance the Raman performance. The 8-mm-long single-crystal diamond was cut for beam propagation along the <110> axis and oriented for the Raman excitation along the <111> axis. Both end faces were anti-reflection coated (R < 0.1%) for the fundamental and the Raman wavelengths.

Fig. 1a shows the output power of the Raman laser up to 67 W of absorbed diode-laser pump power. A maximum power of 2.3 W at ~1400nm was achieved with 3.5% of output coupling. The intracavity power of the fundamental was >420 W. The inset depicts the output spectrum with the fundamental and the Stokes emission centred at 1176 nm and 1394 nm respectively. The Stokes linewidth (FWHM) was <0.05 nm, limited by the instrument resolution. The fundamental peak FWHM was ~0.10 nm. Fig. 1b illustrates the tuning obtained by the rotation of the BRF with no etalons in the SDL cavity. The Stokes wavelength tuned from 1373 to 1415 nm. The frame in the same figure is the image of the Raman beam profile captured by a knife-edge profiler at 1 W of output power. The beam quality factor of the Raman output (M^2) was 1.4. Further characterization will be presented.

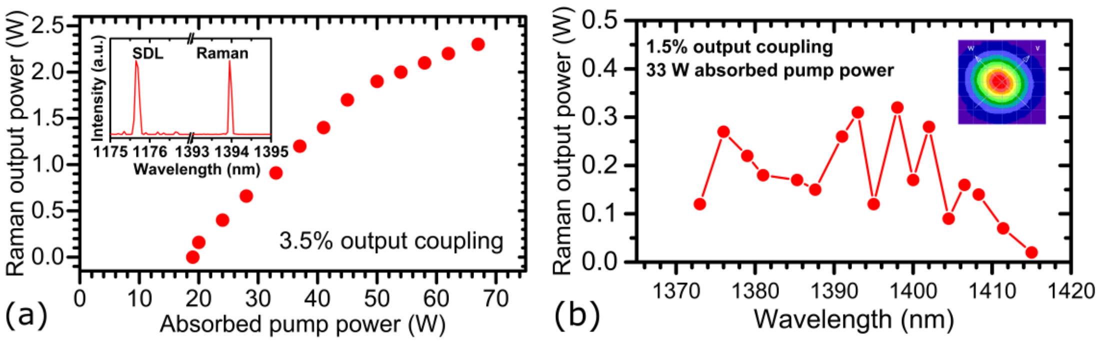

Fig. 1 a) Power transfer of the Raman laser. Inset: emission spectrum of the SDL and the Stokes signals. b) Wavelength tuning of the Raman laser with no etalons in the SDL resonator. Inset: image of the Stokes beam profile.

References

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