

Energy Scaling of Yellow Emission from Monolithic Diamond Raman Lasers

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Recent advances in the growth of low loss single crystal diamond [1] coupled with its high Raman gain and high thermal conductivity have led to the material becoming an established Raman laser material. With applications often having to adapt to available laser wavelengths, Raman lasers can be used as a simple means to shift ubiquitous commercial laser sources to the hard to reach but application rich spectral regions. The authors recently demonstrated a compact, robust monolithic diamond Raman laser shifting 20 μ J nanosecond pulses from a Q-switched 532nm laser to Raman wavelengths of 573nm, 620nm and 676nm with a conversion efficiency of 84%. This work investigates the energy scalability of such a system.

A significant increase in the output pulse energy is reported under pulsed pumping at 532nm. Two devices were tested. Firstly, a 2mm long plano-convex diamond device was implemented, with microlens structures etched onto one surface. When mirror coated, the 13mm radius of curvature (RoC) structure (similar to the one described in [2]) forms a stable cavity with the opposite diamond face, resulting in a TEM₀₀ mode with a radius of 24 μ m. Secondly, a 2mm long plane – plane device, again mirror coated on each face, was explored.

The microlensed system was pumped with an Elforlight FQS laser, delivering near diffraction limited pulses of <5ns duration at energies of 155 μ J at a pump spot radius of 23 μ m. A maximum Raman pulse energy of 92 μ J was achieved (Fig 1a) – a sevenfold improvement on the 13.6 μ J achieved in [2] – consisting of approximately 60 μ J of 1st Stokes and 32 μ J of 2nd Stokes emission (Fig.1(a)). With a cavity mode defined predominantly by the RoC of the microlens, further power scaling of this device is restricted by limitations in the fabrication of longer RoC lenses in order to avoid optical damage to the coatings. With a plane – plane device, however, the cavity mode is less constrained. It is therefore possible to power scale simply by increasing the pump spot radius. Pumping with a Continuum Minilite II laser at a pump spot radius of 195 μ m, 3.1mJ of Raman output power was achieved at a pump pulse energy of 8mJ (Fig.1(b)), a 300 fold increase in Raman output power when compared with the results presented in [2]. The Raman pulse durations were slightly shorter than the pump pulse durations, as expected. First Stokes pulse durations of approximately 2ns and 5ns were measured at rep rates of 10kHz and 10Hz for the microlens and plane – plane devices, respectively. The M² of the microlens and plane – plane devices (1st Stokes) were measured to be 8 and 10, respectively. The effect of the pump beam size on the Raman output beam profile will be presented and analysed. The results cannot be fully explained by the previously hypothesized simple model based on Raman gain guiding [3, 4].

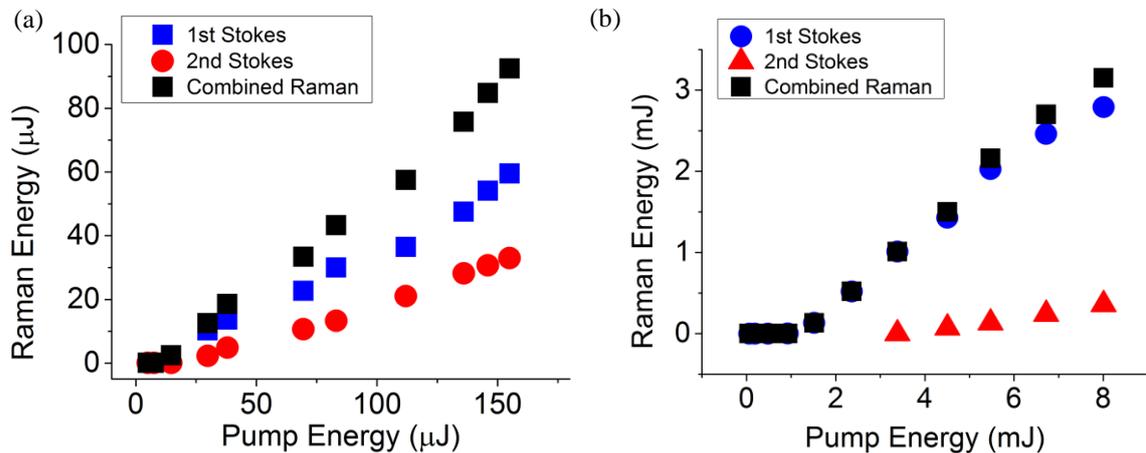


Fig. 1 Power transfer of (a) microlensed monolithic diamond Raman laser and (b) plane – plane monolithic diamond Raman laser.

References

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