Diode-pumped Nd:$GdVO_4$ self-Raman vortex laser at 382 cm^{-1} shift

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Optical vortex sources with wavelength versatility[1)] have been widely investigated in various applications, such as optical trapping, optical communication, quantum optics, and super-resolution fluorescence microscopes. In particular, optical vortex sources based on self-Raman lasers allow us to fill the wavelength gap of conventional solid-state lasers with excellent beam quality[2)]. To date, self-Raman vortex laser sources have been demonstrated, however, they mostly operated at 1.173 μm, corresponding to the stronger transition at 882 cm^{-1} Stokes shift, which has a ~6.4 times larger Raman gain than that of 382 cm^{-1} shift.

In this work, we demonstrate the direct generation of 1.108 μm and 1.173 μm vortex modes from a diode-pumped self-Raman Nd:$GdVO_4$ laser by employing an annular pumping geometry formed of an axicon lens and an objective lens. Figure 1(a) shows a schematic diagram of our system. The pump source was an 879 nm fiber-coupled laser diode, and its collimated output was then focused by an axicon lens to produce an annular pump beam. A focusing lens (IL) and an objective lens (OL) delivered the annular pump beam towards an a-cut 0.3 at.% Nd:$GdVO_4$ crystal. The cavity was formed of the input crystal facet (R > 99.99 % for 1.0-1.2 μm), and a concave output coupler (OC) (R > 99.99 % for 1.063 μm, R = 99.99 % for 1.108 μm). This system, thus, enabled us to achieve the fundamental (1.063 μm), and Stokes outputs (1.108 μm or 1.173 μm). In fact, we obtained selectively stable laser operation of 1.108 μm or 1.173 μm by slight alignment OC, as shown in Fig. 1(b-e). The fundamental output exhibited a high-order mixed transverse mode with a central dark spot, however, interestingly, the Stokes outputs showed a perfect annular spatial profile with a central dark spot in the near and far-fields, owing to beam cleanup effects via the stimulated Raman conversion process[2)]. Furthermore, maximum output powers of 49.8 mW and 133.4 mW for the vortex beams at 1.108 μm and 1.173 μm were achieved at a pumping power of 7.69 W.

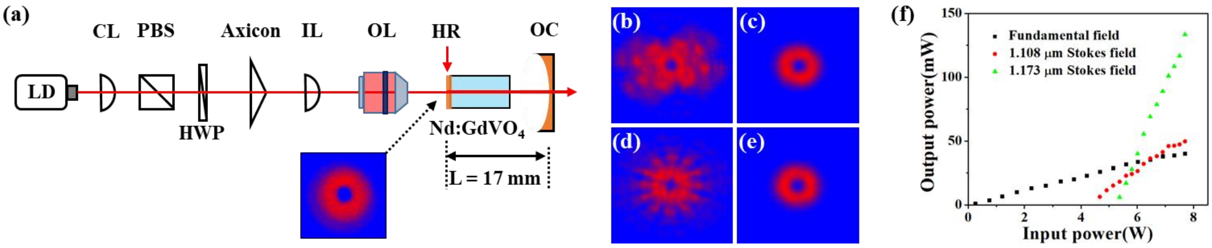

Fig1. **(a)** Experimental setup of a self-Raman Nd:$GdVO_4$ vortex laser. The inset shows the spatial profile of the pumping beam onto Nd:$GdVO_4$ crystal. Near-fields of **(b)** the fundamental (1.063 μm), and **(c)** 1.108 μm Stokes; **(d)** the fundamental (1.063 μm), and **(e)** 1.173 μm Stokes. **(f)** Fundamental and Stokes output powers as a function of pump power.

References

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