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Flashlamp Pumped Lasing of Ho:Germanate Oxide Glass at Room Temperature

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OSA Proc. on Advanced Solid State Lasers, (ASSL) 1994

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We report the first successful flashlamp pumped 2.09 μm lasing at room temperature on the $^5I_7$-$^5I_8$ transition of Ho^{3+} in a germanate oxide glass host.

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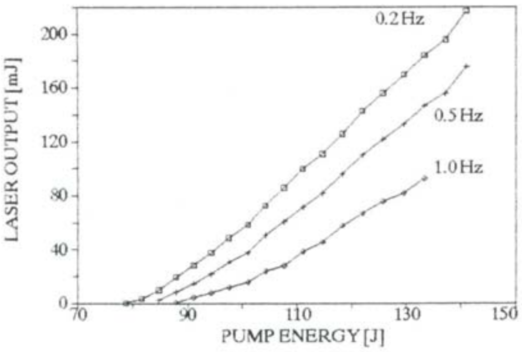
During the 1960's, lasing of Ho^{3+} was obtained in silicate glass hosts at cryogenic temperatures [1,2,3]. These materials exhibited high thresholds and relatively poor overall performance. Subsequent research and commercial applications of 2.09 μm Holmium lasers have focused upon the use of crystalline hosts [4,5,6]. Lasing at 2.09 μm has also been observed in Ho^{3+} doped fluoride fibers pumped by an Argon laser [7]. Unfortunatly, fluoride glass exhibits poor chemical durability and low physical strength, limiting practical applications. This investigation reports on the development of a practical 2.09 μm Ho^{3+} laser glass pumped by a flashlamp at room temperature. To our knowledge, this is the first report of lasing Ho^{3+} in a germanate oxide glass base.

A germanate oxide glass host which exhibited a low multiphonon emission at 2.09 μm was doped with a relatively low concentration of Ho^{3+} and a high concentration of Er^{3+}, Yb^{3+}, and Tm^{3+} sensitizing ions. A low concentration of Ho^{3+} ions was used in the initial trials in order to avoid excessive losses at 2.09 μm due to ground state self absorption. Yb^{3+} and Er^{3+} concentrations were selected for their respective absorption coefficients and the ability for the material to achieve uniform flashlamp pumping in a standard laser rod geometry. The various sensitizer concentrations have been and are currently under investigation to examine the energy transfer between ions. Lasing was not demonstrated in compositions which did not contain thulium.

All glasses were melted in a platinum crucible in order to obtain good optical quality. The absorption coefficient of the hydroxyl radical was measured and maintained below 0.15 cm^{-1}at 2.8 μm. Laser tests were carried out using cylindrical 5 mm diameter, 75 mm long rods pumped with a single linear Xenon flashlamp. The rod ends were polished flat and parallel. The laser rod ends were not AR coated. Deionized water was used as coolant. A 110 mm long resonator consisting of a flat high reflector and output coupler exhibiting 99.9% and 95.5% reflectivity at 2.09 μm, respectively, was used to extract free running efficiency data with the glass rods. The lamp discharge pulse duration was calculated to be 1.9 ms in duration.

Figure 1 illustrates the laser output energy as a function of the energy deposited into the flashlamp for a Ho^{3+} doped, Er^{3+}, Yb^{3+}, Tm^{3+} sensitized germanate glass sample at various repetition rates. The nominal threshold at 0.2 Hz repetition rate was measured to be 79 Joules. The slope efficiency calculated from 100 to 140 Joules input energy was 0.4%. It is expected that the threshold and efficiency of this laser material will improve significantly after compositional optimization and the application of antireflection coatings to the faces of the test rods. Figure 1 illustrates a downward trend in output energy that is inversely proportional to the pulse repetition rate. This is due to elevated rod temperatures and thermal lensing effects.

Figure 1.
Laser output energy as a function of the energy deposited into the flashlamp for Ho^{3+}:Germanate glass.



The free running laser wavelength was measured with a grating spectrometer. It was centered at 2.093 μm and had a line width of 22 nm. Figure 2 illustrates the Gaussian distribution of output energy. The relatively wide line width suggests that this material should be tunable over a relatively large range.

Figure 2.
Distribution of output laser energy.

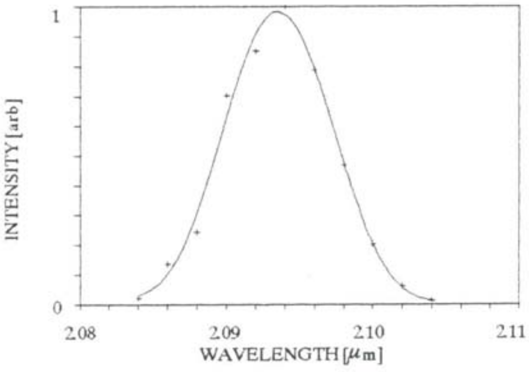
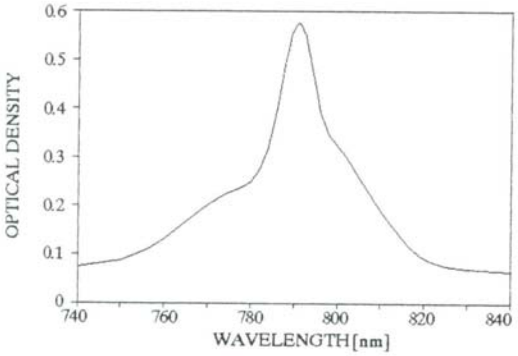


Figure 3 shows the absorption spectra of the Tm^{3+} ion in a germanate base from 740 to 840 nm. This absorption band has proven to be very useful for diode pumped Ho^{3+} crystalline lasers. This 12 nm FWHM absorption line width is much wider in the germanate glass host than that in crystalline materials [4]. Additionally, the Tm^{3+} concentration may be varied over a wider range in glass than in crystals. This implies that Tm^{3+}, Ho^{3+} doped germanate glass is also a promising candidate for semiconductor or laser pumping.

In conclusion, we have demonstrated the first flashlamp pumped, room temperature

Figure 3.
Absorption spectra of Tm^{3+} in a germanate glass.



Ho^{3+} doped germanate oxide glass laser operating on the $^5I_7$-$^5I_8$ transition with Er^{3+}, Yb^{3+}, and Tm^{3+} sensitizers. The Ho^{3+} glass laser output should be tunable over a relatively large range. The initial test data indicates that this new Ho^{3+} doped germanate oxide glass is a promising candidate for operation in the 2 μm region with enhanced flashlamp, diode, and laser pumping.

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