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A samarium doped visible glass laser operating at 651 nm.

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Abstract.
Laser emission at 651nm has been observed from samarium^{3+} doped silica optical fibre in a Fabry-Perot type laser cavity. The laser operates in cw and Q-switched modes when pumped with 488nm light at room temperature.

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We report continuous wave laser emission from a samarium^{3+} doped silica fibre laser on a transition hitherto unreported in any material. Previously laser emission has only been observed from samarium^{3+} in a crystalline host[3] with emission at a different wavelength (593 nm) when cooling to 116K was required.

A silica optical fibre of na 0.18 and second mode cut-off at 620nm containing 250 molar ppm of samarium^{3+} ions was prepared by a solution doping process [4].

The fibre absorption at 651 nm was measured to be 50 dB/km and 2000dB/km at the pump wavelength (488nm) as shown in figure 1. When pumped at 488 nm the fluorescence spectrum shows the majority of radiation in the 651 nm band. The 1/e fluorescence lifetime of the $^4G_{5/2}$ level was measured to be 1.68 ms although the decay is seen to be characteristically non-exponential indicating an inhomogeneous broadening component in the line-width. Samarium $^{3+}$ in silica glass is particularly interesting because the absorption to and fluorescence line-widths from the $^4G_{5/2}$ level are much narrower (3nm) than seen in other rare-earth doped glasses. This can be partially attributed to transitions to and from only one Stark component of the $^4G_{5/2}$ level. Stimulated emission occurs between the $^4G_{5/2}$ and $^6H_{9/2}$ levels corresponds to 651 nm light and is a 4-level transition.

The laser is a Fabry-Perot resonator consisting of dielectric mirrors with reflectances at the laser wavelength of 651nm of 99% and 60% to provide optical feedback. The samarium doped fibre is cleaved and butted up to the mirrors. Optical pumping is achieved by launching up to 1W of optical power at 488 nm into the fibre. The lasing characteristic of this device is shown in figure 2. Lasing thresholds of 20mW absorbed pump power with a slope efficiency of 12.7% are obtained in this configuration. The threshold has been reduced to 2mW by increasing the output mirror reflectivity to 93%.

Pulsed Q switched operation of the laser is achieved by inserting a lens and a rotating chopper into the laser cavity. Pulses of peak power 8W and width 144ns were achieved (figure 3).
We have demonstrated laser action in samarium doped silica optical fibres. We believe this to be the first report of laser action in a samarium^{3+} doped glass. In addition laser emission due to the $^4G_{5/2}$ to $^6H_{9/2}$ transition in samarium $^{3+}$ has not been observed in any material prior to this work. This laser material is advantageous because it produces visible light from a narrow transition with a long meta-stable lifetime.