Fabrication of a single mode laser by UV-writing in neodymium doped silica-on-silicon.

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Abstract: We describe the fabrication of a waveguide laser by UV-writing in neodymium-doped silica-on-silicon. The substrate is fabricated by Flame Hydrolysis Deposition and solution doping techniques. Lasing at 1048-1056nm was observed with a slope efficiency of 33% and threshold of 4mW for the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition. Lasing was also observed at 1356nm.

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Rare earth doped glass waveguide lasers have been demonstrated using a number of fabrication techniques, one of the earliest results being achieved using a combination of flame hydrolysis deposition (FHD), solution doping and reactive ion etching (RIE) [1]. The need for versatile, cheap laser sources makes direct-UV-writing an interesting technique as it allows rapid prototyping towards the fabrication of low cost integrated optical components. Silica-on-silicon allows simple mode matching to standard telecom fibre [2].

Direct UV writing allows waveguide structures to be drawn into a photosensitive core layer by scanning of the layer under a focussed UV beam [3], thanks to a localised change in refractive index induced by short wavelength radiation. We present the first demonstration of direct-UV-written waveguide lasers in neodymium-doped silica-on-silicon.

Fabrication of the FHD samples used was performed by depositing low-density oxide soot produced from chlorides of Si, Ge, P and B to form a core layer. The neodymium was introduced inside the core layer by solution doping [1] and the neodymium concentration was later measured as 1.26wt% from Secondary Ion Mass Spectrometry (SIMS). The soot layer was subsequently sintered to give a fully dense glass layer.

Hydrogen loading of the sample at 150 bars for >5 days was performed to increase the sample photosensitivity. Direct UV writing into the photosensitive core layer was performed using a frequency doubled argon ion laser at 244nm and characterisation of laser performance and propagation loss of the subsequent laser channel waveguide devices was performed with a tunable Ti-Sapphire laser.

Laser action was achieved in the Nd $^4F_{3/2}\rightarrow{}^4I_{11/2}$ transition by butting plane mirrors to the end faces of the device and pumping at 810nm. The lowest pump power required to reach threshold was 4mW of absorbed power, using two high reflectivity mirrors. With a 25% output coupler, a threshold of 11mW and a slope efficiency of 33% were observed.

Lasing occured across a wavelength range of 1048-1056nm and laser action in the Nd $^4F_{3/2}\rightarrow{}^4I_{13/2}$ transition at 1356nm at a threshold of 370mW.

In all cases, the laser output was in the fundamental spatial mode, with Gaussian mode profile in both guided directions. A guided output spot size of 4.4x6.9µm was measured at 1050nm.

From the threshold results, a value of 0.06cm^{-1} to 0.08cm^{-1} was calculated for the propagation loss coefficient α with different output couplers, corresponding to a waveguide propagation loss of <0.3dBcm^{-1}. This result was confirmed with a separate calculation of the slope efficiency, giving an upper limit for propagation loss of 0.8dBcm^{-1}.

We have reported a fabrication technique for the production of low-threshold single mode laser channel waveguides in Nd-doped silica-on-silicon substrates, with lasing wavelengths of 1048-1056nm and 1356nm. Characterisation of laser performance in the channel waveguides demonstrates milliwatt-order laser thresholds, single spatial mode operation, and propagation losses <0.8dBcm^{-1}. This result demonstrates a planar waveguide laser in the silica-on-silicon format, which combines good lasing characteristics with photosensitivity to allow UV definition of waveguides.

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