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Ridge waveguide lasers based on fs-laser writing on rare-earth doped crystals

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The fs-laser writing technique is an interesting and versatile approach to fabricate ridge optical structures in dielectrics, defining the so-called type-IV direct written waveguides [1]. The fs-laser ablation is used to remove the selected parts of the planar waveguide surface, constructing thus the ridges. This technology does not require the use of clean room facilities, and allows rapid prototyping of integrated photonic devices because it is a mask-less technology.

Among other integrated photonic devices, waveguide lasers in crystalline media are attractive to be used as miniaturized laser sources [2]. In particular doubles tungstates (KYW) and lithium niobate ($LiNbO_3$) are good candidates for laser hosts when doped with active rare earths, such as Yb or Nd, operating around 1 μm wavelength [3, 4].

In this work, we demonstrate laser operation is waveguide configuration based on Yb:KYW and Nd:$LiNbO_3$ fabricated by fs-laser written technology to create the ridges waveguides. The ridge waveguides are defined by structuring active planar waveguides with femtosecond laser machining. Here two types of planar waveguides have been using to design the waveguide lasers: step-index waveguides (by using liquid phase epitaxy on double-tugnstate crystals) and gradient index waveguides (by using metallic diffusion on lithium niobate crystals). A mirrorless Yb^{3+} doped $KY_{1-x-y}Gd_xLu_y(WO_4)_2$ waveguide laser with cw operation at 981.5 and 1001 nm, fabricated by liquid phase epitaxy and structured by femtosecond laser microstructuring, is first reported. The planar waveguide was fabricated by growing an Yb^{3+} doped $KY_{1-x-y}Gd_xLu_y(WO_4)_2$ epitaxial layer by liquid phase epitaxy over a $KY(WO_4)_2$ substrate. This planar waveguide was then microstructured by means of multiplexed beam femtosecond laser writing technique to define ridge waveguides. Mirrorless laser action is demonstrated in ridge waveguides with different fabrication parameters, obtaining maximum slope efficiency above of 78% versus absorbed power (see figure 1), On the other hand, ridge waveguide lasers have been also fabricated on Nd^{3+} doped $LiNbO_3$ crystals. The fs-laser writing technique was used to define ridge structures on a gradient-index planar waveguide fabricated by Zn-diffusion. This planar waveguide was formed in a *z*-cut $LiNbO_3$ substrate homogeneously doped with a 0.23% of Nd^{3+} ions. By butting two mirrors at the waveguide end-facets, TM-polarized laser action at 1085 nm was achieved, which shows a threshold of 31 mW, with a 7% of slope efficiency, thus confirming the feasibility of this technique for the development of integrated laser devices.

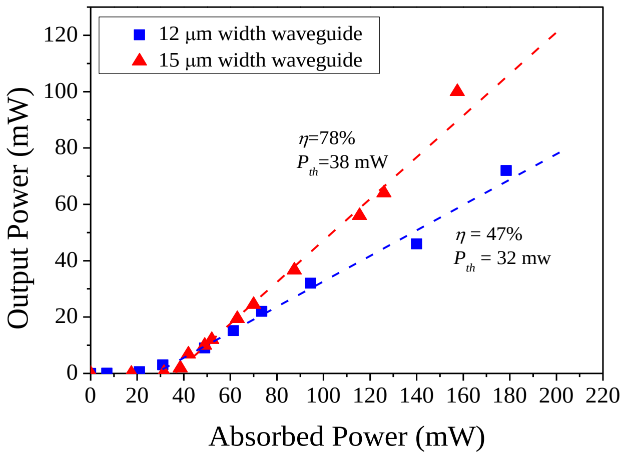

Fig. 1. Laser performance of a 12 and 15 µm width Yb:KYW ridge waveguide operating at 1001 nm.

References

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