High-index contrast waveguides in potassium double tungstates: towards rare-earth ion doped on-chip integrated photonics

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Abstract

In recent years, low-contrast waveguides in rare-earth ion doped potassium double tungstate crystalline material have enabled the demonstration of very efficient (>80%[1]) waveguide lasers exhibiting high output power (1.6 W in a Tm^{3+} doped waveguide[1] and >650 mW in an Yb^{3+} doped device[2]). Tunability over 55 nm bandwidth was demonstrated by the use of an external grating[3]. The wavelength of. Er[3] doping is currently being studied for on-chip amplification in the C-band[4]. Ytterbium (Yb^{3+}) and thulium (Tm^{3+}) have been studied in recent years for laser operation wavelengths around 1 and 2 μm respectively. The great performance of these devices is due to the combination of material properties, such as the high absorption and emission cross-sections of the rare-earth ions doped into this crystalline host material, the high dopant concentration that can be utilized due to the large (~0.5 nm) interionic spacing defined by the crystal lattice and a long excited state lifetime (from >260 μs in Yb^{3+} to a few milliseconds in Er^{3+}), with waveguide configuration, which increases the field intensity inside the waveguide core. Those factors increase the achievable modal gain, permitting the realization of low threshold high slope efficiency devices.

However, the aforementioned demonstrations utilized doped RE:$KY(WO_4)_2$ layers epitaxially grown onto undoped $KY(WO_4)_2$ substrates, leading to relatively large waveguide cross-sections. The large mode supported by those waveguides increases the power requirement for both the inversion of the gain material and the observation of non-linear effects. Furthermore, the size of the devices is large (i.e., centimeter range), not being suitable for on-chip integration onto passive photonic platforms such as silicon-on-insulator (SOI) and Si_3N_4/SiO_2.

In this presentation, the recent advances towards the realization of high-index contrast waveguides[5] in rare-earth ion doped $KY(WO_4)_2$ will be given as well as two potential integration schemes to SOI and Si_3N_4/SiO_2 platforms[6]. These realizations represent the first milestones towards the demonstration of very efficient on-chip active devices in this material, which will permit the realization of novel integrated devices exploiting its excellent gain and non-linear properties.

References

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