Highly efficient lasers and amplifiers in double tungstates

M. Pollnau, D. Geskus, K. van Dalfsen, S. M. García-Blanco, and S. Aravazhi

The double tungstates $KY(WO_4)_2$, $KGd(WO_4)_2$, and $KLu(WO_4)_2$ are excellent candidates for solid-state lasers because of the large transition cross-sections of optically active rare-earth ions doped into these hosts. We grow actively doped $KY_{1-x-y}Gd_xLu_y(WO_4)_2$ layers onto $KY(WO_4)_2$ substrates by liquid-phase epitaxy. Co-doping the layers with optically inert Gd^{3+} and Lu^{3+} ions simultaneously allows for lattice matching and enhanced refractive index contrast with respect to the substrate. Low-loss channel waveguides are microstructured into the layers by Ar^+-beam etching, resulting in strong pump- and signal-mode confinement. Yb-doped channel waveguide lasers deliver 650 mW output power at 1 µm. Record-high slope efficiency (85%) and record-low quantum defect (0.7%) for dielectric lasers are achieved. In pump-signal experiments, exploiting highly doped $KGd_{0.447}Lu_{0.078}Yb_{0.475}(WO_4)_2$ channel waveguides, we demonstrate a giant optical gain of 950 dB/cm, exceeding the gain previously reported in rare-earth-ion-doped materials by two orders of magnitude and comparable to the gain obtained in semiconductor optical amplifiers.