Semiconductor laser pumped rare earth ion doped solid-state lasers in the visible and near infrared spectral region

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The talk reviews the basic concepts of advanced highly efficient rare earth ion doped solid-state lasers based on laser ions such as Yb^{3+}, Tm^{3+}, Er^{3+}, Pr^{3+}, and Tb^{3+} which have opened new prospects for laser applications at various wavelengths and power regimes. The main emphasis is placed on the interplay between materials aspects and most relevant spectroscopic as well as laser related properties in the search for new solid-state laser systems.

For the near infrared spectral region Yb^{3+}-doped laser crystals feature very high efficiencies and reduced heat generation due to small Stokes-losses between pump and laser photons. In particular, Yb^{3+}:Lu_2O_3 possesses high thermal conductivity and have been operated at record slope efficiencies of 80% in continuous wave operation and at more than 100 W of average power in the mode-locked sub-ps operation regime. Laser diode pumped, highly efficient 2-μm Tm^{3+}- and 3-μm Er^{3+}-lasers with special interest for medical applications are based on interionic interactions of Tm^{3+} and Er^{3+} laser ions, respectively.

Breakthroughs regarding efficient visible coherent light generation have been achieved with Pr^{3+}- and Tb^{3+}-lasers operating in the green, orange, and red spectral region under blue semiconductor laser pumping. Here both, the development of blue semiconductor pump lasers and the use of suitable short wavelength hosts with minimized excited state absorption of the laser ions contributed to major achievements.

The functionality of laser crystals can be further increased by direct micro-structuring of bulk crystals with ultrafast laser pulses yielding for instance efficient waveguide lasers with diffraction limited, fundamental modes in the near infrared and visible spectral region. This simple direct light writing technique is also suitable for the fabrication of more complex structures for integrated optics in single crystalline dielectrics.