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Power conversion efficiency of solar-pumped solid-state 4-level lasers

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The first solar-pumped lasers required highly concentrated sunlight to surpass high lasing thresholds. Nd:YAG waveguides sensitized by luminescent nanocrystals reached lower thresholds and were further improved by co-doping ions with broad vibronic absorption bands, e.g. Cr^{3+}, providing high efficiencies. Alternatively Yb:YAG could be sensitized by Nd3+ with efficient energy transfer, rendering co-doped Ce, Cr, Nd, Yb:YAG ceramics promising candidates for high-efficiency solar lasers. Comparing the laser output power with the direct normal irradiance (DNI) of sunlight, power conversion efficiency (PCE) can be defined in analogy to photovoltaic systems. This efficiency is quite different from a conversion efficiency of a pump rate at fixed wavelength (e.g. diode pumping), as it includes the solar spectrum, that is only partly absorbed within certain spectral bands by the active laser medium. The PCE is increased by high broadband absorption cross sections that ideally cover dominant parts of the solar spectrum, as realized today using novel co-doped YAG materials. However, high PCE and low lasing threshold depend also on a large overlap of the intensity distribution of concentrated sunlight with the laser mode. Pumping may be improved, e.g. by fibers that are efficiently focused into the gain medium. In this contribution the PCE of a solar-pumped laser using co-doped YAG ceramics is studied theoretically using four-level laser rate equations. It will be shown how the PCE depends on the spectral absorption cross section of the laser medium and on the intensity overlap of pump and laser light within the laser medium. Of particular interest will be the optimal absorption cross section of the lasing material in terms of spectral shape and quantum defect of the laser medium, which is of relevance for the design of future laser materials.

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Biography

Sascha Wallentowitz is associate professor at Instituto de Física, at Pontificia Universidad Católica de Chile and is working in quantum and nonlinear optics. He studied physics at Universität Ulm, Germany and did his doctorate degree at Universität Rostock, Germany. Birger Seifert is associate professor at Instituto de Física, at Pontificia Universidad Católica de Chile and is working in quantum and nonlinear optics. He studied physics and did his doctorate degree at Universität Rostock, Germany.

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