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Numerical Investigation of Mid-Infrared Laser Action in Pr^{3+} Doped Chalcogenide Fibre Laser

L. SÓJKA[1,2], Z. TANG[1], D. FURNISS[1], H. SAKR[1], E. BEREŚ-PAWLIK[2], A. B. SEDDON[1], T. M. BENSON[1], S. SUJECKI[1*]

[1]George Green Institute for Electromagnetics Research, University of Nottingham, University Park, NG7 2RD Nottingham, UK

[2]Telecommunications and Teleinformatics Department, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland

* slawomir.sujecki@nottingham.ac.uk

High power mid-infrared fibre laser sources with emitting wavelengths covering the range stretching from 4 μm to 5.5 μm offer many applications in remote sensing, medicine and defence [1]. However, in order to access these wavelengths, low phonon host materials are needed. Among the most promising host materials for this wavelength region are chalcogenide glasses [1]. Chalcogenide glasses possess good rare earth ion solubility, high refractive index and can be drawn into fibre. These characteristics make chalcogenide glasses a promising host material for rare-earth ions [1-4]. Recent publications show that there is a particularly large interest in mid-infrared fluorescence from the ($^3F_2$,$^3H_6$) → $^3H_5$ (~3.7-4.2 μm), and $^3H_5$→ $^3H_4$ (4.3-5.0 μm) transitions of Pr^{3+} doped selenide glass [2-4]. This is because Pr^{3+} in chalcogenide glass has a high pump absorption cross-section, and also because it can be pumped with commercially available laser diodes. In order to achieve the first mid-infrared laser action in chalcogenide glass fibres the population mechanisms need be understood in detail.

Numerical modelling of Pr^{3+} chalcogenide doped fibre laser is presented in this paper. The spectroscopic parameters were extracted from in-house prepared selenide Pr^{3+} doped chalcogenide glass samples and used in modelling. In this contribution particular attention is paid to pumping schemes. The cascade scheme already reported in literature[4] is compared to a resonant pumping scheme. Additionally, the laser performance was tested against pump wavelength, fibre length, signal wavelength, and output coupler reflectivity. The modelling results show that the proposed resonant pumping scheme using a high power QCL pump is a better solution than an indirect pumping using a 2.1 μm laser. The results obtained show also resonant pumping allows for a significant reduction in the laser threshold and an increase in the laser efficiency when compared with cascade lasing.

References

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